BOILING PROCESS ENHANCEMENT FOR THERMOSIPHON POROUS SURFACE WITH NANO-FLUID

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Abstract

The increase of the heat transfer coefficient in a heat exchanger is the basic task of our research. It has been obtained by the phenomena of thermosiphon. The boiling heat transfer on porous surface with nanofluid has been studied for the first time. The results of our experiments have shown that in the case of porous heating surfaces, heat transfer during boiling of distilled water increases. Use of porous surfaces with addition of SAS in boiling liquid gives a possibility to manufacture more compact heat exchangers, to decrease dimensions of working surface that will significantly decrease material consumption and power consumption during manufacture of heat exchangers.

KEYWORDS

Thermosiphon, porous surface, nanofluid, heat transfer.

INTRODUCTION

In these researches the thermosiphon cooling system using porous heating surfaces and nanofluid solutions water + surface active substance (SAS) has been investigated. Experiments have shown that there is considerable improvement in performance characteristics of a cooling system.

Compactness of heat exchangers is characterized by having comparatively a large amount of surface area in a given volume compared to traditional heat exchangers, or very high heat transfer coefficients compared to traditional heat exchanger values.

The increase of the heat transfer coefficient in a heat exchanger is the basic task of our research. It has been obtained by the phenomena of thermosiphon. The boiling heat transfer on porous surface with nanofluid has been studied for the first time. The results of our experiments have shown that in the case of porous heating surfaces, heat transfer during boiling of distilled water increases. Use of porous surfaces with addition of SAS in boiling liquid gives a possibility to manufacture more compact heat exchangers, to decrease dimensions of working surface for heat pick-up that will significantly decrease material consumption and power consumption during manufacture of heat exchangers.

The thermosiphon type compact heat exchanger with porous surface and boiling of nanofluid has the following innovation and advantages:

- enhancement of heat transfer for boiling of water solutions with SAS;
- high efficiency;
- smaller weight and size;
- low cost;
- simple control;
- without inertia and reliable;
- work without consumption of energy;
- automatic and independent modes of operation;
- noiseless.

The application areas include computer technology, telecommunications, metrology, avionics consumer electronics, automotive engineering medicine, biotechnology, office equipment and home appliances, safety technology, process engineering, and environmental protection.

For thermal/fluid systems using microelectromechanical systems (MEMS), the large number of thermo-devices enables us to consider a closed-loop thermosiphon control through disturbances generated by micro-flaps or micro-droplets. Transport phenomena are critical to the advancement of MEMS. Similarly, MEMS devices can be applied to create new thermosiphon systems. The investigation of a heat transfer on porous media and in microchannels is the actual problem now [1–4].

For investigation of this process we have mounted experimental installation (Fig. 1).

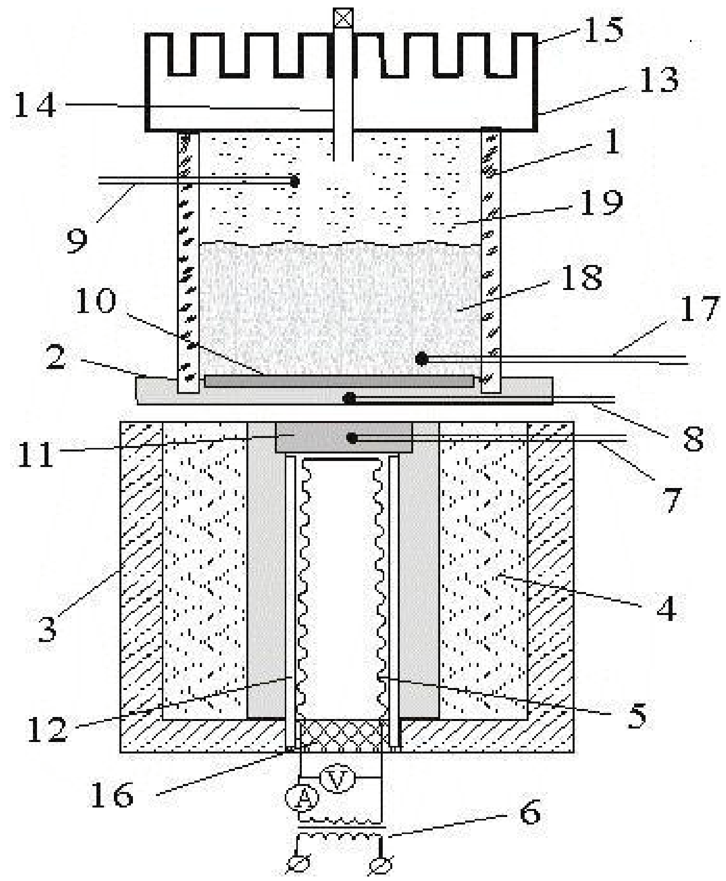

Fig. 1. Experimental installation: 1 – vessel (quartz tube), 2 – evaporator’s bottom, 3 – ceramic tube, 4 – asbestos, 5 – heater (nichrome wire), 6 – transformer, 7, 8, 9 – thermocouples, 10 –porous heating surface, 11 – copper heater, 12 – mica film, 13 – aluminium condenser, 14 – signalization valve, 15 – ribs, 16 – isolation, 17 – thermocouple, 18 – nanofluid water+SAS, 19 – vapour

On the given experimental installation the investigations of influence on boiling heat transfer at different nanofluid solutions [5] water+SAS of the following factors were conducted:

- Diameter of the quartz tube (1, Fig. 1);
- High of the quartz tube;
- Quantity of cooling liquid in the quartz tube;
- Special macroroughnesses on an outside surface of the condenser;
- Special microroughnesses on an interior surface of the condenser;
- Quantity of a heat-transfer coefficient on an outside surface of the condenser;
- Quantity of the area of an outside surface of the condenser;
- Ambient temperature;
- Velocity of air cooling on a surface of the condenser;

- Cooling of an outside surface of the condenser by a fluid;
- Physical characteristics of a fluid in a thermosiphon;
- Heat transfer coefficient of a porous heating surface (with different pore diameters).

The influence of surfactant solutions on boiling heat transfer has been investigated by many authors [6-10]. In our research we have studied influence of different nanofluid solutions distilled water+SAS (dodecyl sulfate of sodium $CH_3(CH_2)_{12}OSO_3N_9$) on boiling heat transfer coefficient. The results of experiments are shown on the Fig. 2.

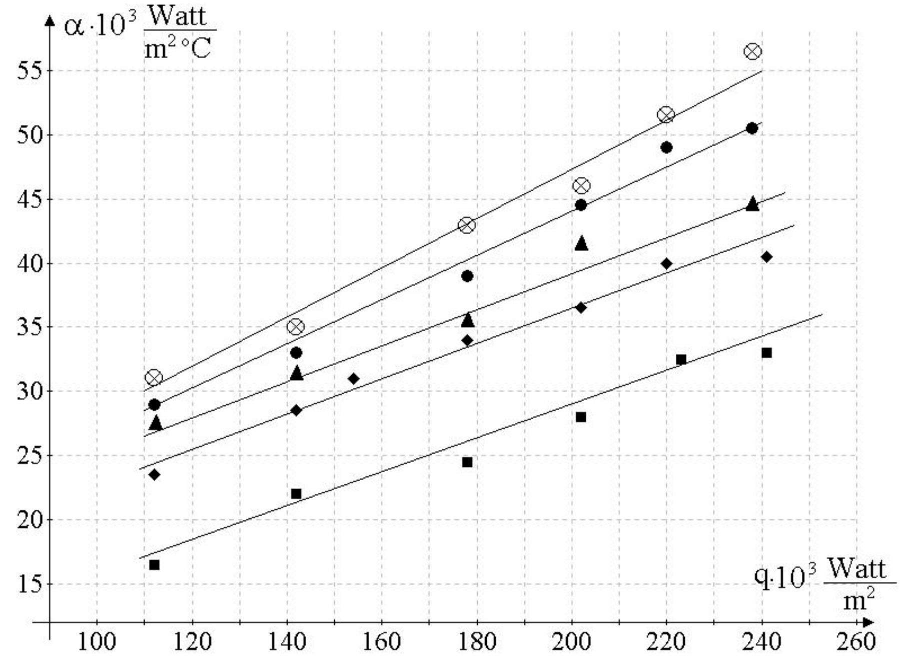

Fig. 2. Influence of heat fluxes on heat transfer coefficient for various nanofluid solutions (ppm) distilled water+SAS: ■ – distilled water on a solid cooper surface, ♦ – distilled water on a porous (layer thickness 0.1mm) cooper surface, ▲– nanofluid solution water+SAS 50 ppm solution on a porous (layer thickness 0.1mm) cooper surface, ● – nanofluid solution water+SAS 100 ppm solution on a porous (layer thickness 0.1mm) cooper surface, ⊗ – nanofluid solution water+SAS 200 ppm solution on a porous (layer thickness 0.1mm, diameter of pores 10 micron) cooper surface

From our investigations follows, that at increase of SAS (dodecyl sulfate of sodium) concentration in water from 50 ppm up to 200 ppm heat transfer coefficient increases almost for 30 %. It enables to reduce the working area of heat exchanger and to improve its factor of compactness.

The effect of enhancement of heat transfer at boiling of nanofluid solution distilled water+SAS is connected to the following factors: babble nucleation process, babble departure diameter and frequency, number of active centers on heating surface [11, 12].

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