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Study of the Heat Transfer Ability of a Capillary-Porous Cooling System in Heat Power Installations

Alexander A. Genbach[1], David Yu. Bondartsev[1] and Hristo Beloev[2]

[1]*Almaty University of Power Engineering & Telecommunications (AUPET), Faculty of heat energy, Almaty, Kazakhstan*
[2]*"Angel Kanchev"University of Ruse, Ruse, Bulgaria*

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Abstract

The proposed new capillary-porous cooling system can significantly impact on the increase of the initial parameters of the thermodynamic cycle of power installations. This however would come at the expense of extracting high-level relative heat flows.
The results of the theoretical calculations have been confirmed by the experimental studies carried out for cooling systems with capillary-porous structures. The studied capillary-porous system, in which capillary and mass forces work together, has an advantage over boiling at large volumes, thin-film evaporator as well as over heat pipes. Moreover, it makes it possible to control the intensity of heat and mass exchange.
Our studies have a practical application in the protection of thermally loaded surfaces of power installations against destruction. We carried out experiments examining the transitional mode of operation of power installations and for the creation of capillary-porous cooling systems.
Novel findings: These are expressed in the synthesis of various heat exchange and hydrodynamic processes taking place in capillary-porous systems. Examined were boiling processes - at large volumes on technically smooth surfaces, in heat pipes and in thin-film evaporators. A new capillary-porous cooling system is proposed, which combines the action of both capillary and mass forces – this is the novelty.
Originality of the model a real capillary-porous system taking into account coolant overflow is presented. In this system capillary forces ensure the equal distribution of liquid, and mass forces – the destruction of the steam conglomerates formed, along with expanding the limit of heat flux extraction. The given model was tested under experimental conditions and allowed us to obtain the general equation in qcr.
Novelty of the experimental method: the following were investigated for the first time: the various factors and their influence on the heat exchange of a new capillary-porous system; new capillary-porous coatings on an experimental setup, which reached burner torch temperatures of up to 2500ºC, and heat flows in said coatings of up to 2×10^7 W/m^2. These heat flows are extracted without the destruction of the capillary-porous coatings. During this process working temperatures of the gas turbine unit's coatings reached 1700ºC. Novelty of the calculation, which differentiate it from previous works: The calculation using equation (qcr) was only possible as a result of the synthesis of multi-year targeted research of a new capillary-porous cooling system (on the experimental setup).
Equation (qcr) was obtained following studies on the influence of various heat exchange parameters $(\rho, \bar{\upsilon}, b, \delta, \beta)$
The theoretical calculations have been confirmed by the experimental studies carried out for cooling systems with capillary-porous structures and coatings.
These equations differ from all other equations for the limit state of the heat exchange process in boundary conditions. The novelty is in the fact that they allow for calculations of capillary-porous coatings to be carried out, which we have shown using a power installations.
We developed various kinds of structures, made from standard metallic meshes, commonly used in industry, for the implementation of the studied capillary-porous cooling system.
The scientific paper examined options for reducing the levels of noisy signals and their identification using artificial neural structures. Single linear neurons were applied to sinusoidal signals with added Gaussian White Noise and Periodic Random noise. The changes of the Sum Squared Errors are monitored by selecting their minimum values, which achieve the lowest noise levels. Artificial neural structures were created to identify square waveforms with superimposed Uniform Gaussian Noise and Periodic Random Noise. Various types of activation functions and neuronal units were tested in the hidden layer of neural models by examining the metrics - Accuracy and Mean Squared Error. The highest accuracy of 94.00% achieved was obtained by hyperbolic tangent sigmoid activation function.

Keywords: capillary-porous coatings, thermoelasticity, compression stresses, tensile stresses, model, thermal power plant.

*E-mail address: d.bondartsev@inbox.ru
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