MATHEMATICAL MODELING HEAT TRANSFER IN CLOSED TWO-PHASE THERMOSYPHON

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МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ТЕПЛОПЕРЕНОСА В ЗАМКНУТОМ ДВУХФАЗНОМ ТЕРМОСИФОНЕ

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Проведен численный анализ теплопереноса в замкнутом двухфазном термосифоне цилиндрической формы в условии подвода теплоты на нижней крышке. Для описания исследуемого процесса предложена упрощенная математическая модель, отличающаяся от известной описанием только процессов теплопроводности в системе «корпус термосифона – паровой канал – пленка конденсата». Сформулированная краевая задача решена методом конечных разностей. Получены поля температур в термосифоне для типичных тепловых нагрузок и режимов работы.

Heat pipes [1] and thermosyphons [2] are perspective systems of cooling for different equipments. But while thermosyphons are used rarely. It is related to lack of general theory heat transfer convection processes in such systems, which provides possibility of their practical elaboration. Mathematical models [3,4], used for description [2] of processes of convection in a steam channel and membrane of refrigerant in thermosyphons, are difficult. It is expediently to elaborate less difficult (as compared to [3,4]) models, taking into account the thermal effects of evaporation and condensation of refrigerant, and also heat conductivity.

The aim of this work is a mathematical simulation of temperature fields of closed two-phase thermosyphons.

Is examined thermosyphon the principle layout of which is shown on figure 1. Energy of source of heat emission, which is located near-by the lower lid of thermosyphon, enters in zone of evaporation of refrigerant through the border $z=z_1$. As a result of intensive vaporization there is drop in pressure. Steams quickly move to the high bound of steam channel, temperature of which below temperature of condensation of the material which used as refrigerant. Steam condenses. An appeared liquid under influence of gravity flows down on vertical walls of steam channel and spreads on surface of lower lid of thermosyphon. Processes of evaporation and condensation continue during the period of addition of heat on a low bound and taking from the high bound of lid of thermosyphon. Phase transitions on scopes of section of phases provide taking of warmth from equipment that gives of warmth. In majority practically meaningful applications thermosyphons work during the protracted periods of time in stationary modes. Therefore at raising of task of heat transfer, row of assumptions is possible. The followings are basic.

1. Characteristic times of motion of steams in the channel of thermosyphon much less than characteristic times

of heat conductivity in liquid membrane on lower and overhead lids of thermosyphon, therefore the processes of motion of steam in channel of thermosyphon are not examined.

2. In the stationary modes descriptions of process of motion of membrane of condensate on the side of steam channel do not depend on time, therefore a thickness of membrane of refrigerant can be accepted as permanent at raising of task.

Formulated assumptions do not give important limits on raising of task. In the complex of processes of heat–mass transfer in thermosyphon during its work basic are phase transitions on low and overhead bounds of steam channel. At permanent intensity of evaporation of liquid (and also condensation of steams on overhead lid) condensate will go back into zone of admission of warmth under action of gravity with speed, which is not depend on speed of its evaporation on the low bound of steam channel. With growth of intensity of vaporization in channel (2) drop in pressure increases (fig.1) and speed of uplift of steams to surface of condensation also. It is always possible to estimate limit values of parameters of motion membrane of runback, under reaching which can be a crisis of "complete boil-off of refrigerant" on lower lid of thermosyphon. Pursuant, to design within of Navier –Stoks [3,4] or Prandtl's [2] models of motion of steams in channel (2) and membrane of runback (3), cannot in several practically meaningful cases give substantial changes of integral descriptions of heat transfer during thermosyphon's work.

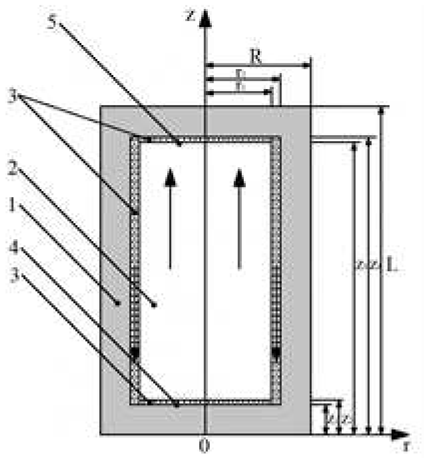
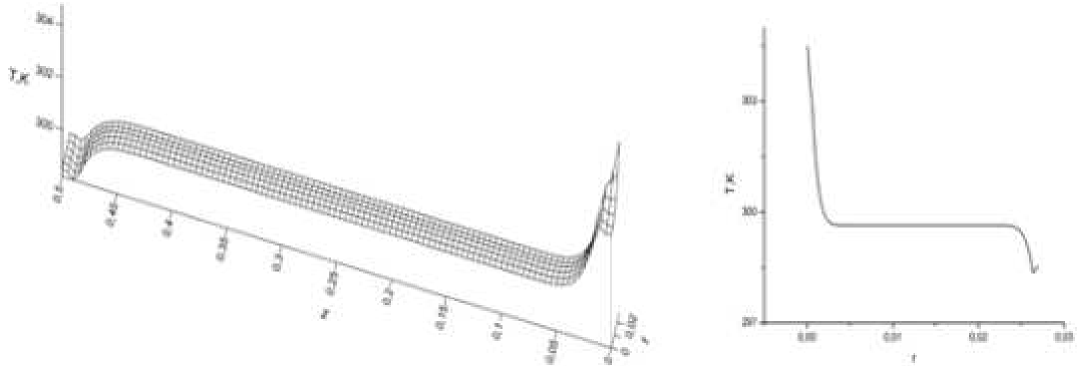


Fig. 1. Chart of the closed thermosyphon: 1 – metallic corps; 2 – steam channel; 3 – membrane of liquid; 4 – surface of evaporation; 5 – surface of condensation. Vertical pointers show directions of motion of steam and liquid.

Also decision of complete system equalization of viscid liquid [3,4] at description of motion of steam in a channel (2) can result to increase of time of calculations. Even passing to model of boundary layer [1] is attended with the protracted calculations at decision of task of heat transfer in thermosyphons. Therefore chosen assumptions at raising of task are creates objective pre-conditions for substantial decline of expenses of time at its decision in condition of account of basic meaningful factors and processes.

The process of heat transfer in examined thermosyphon (fig.1) within of accepted physical model is described by system of differential equalizations of heat conductivity in partial derivative with proper boundary conditions.

The system of differential equalizations in partial derivative with nonlinear boundary conditions decided by the method of eventual differences. For decision of more complicated problems of heat transfer in conditions of attended heat exchange in multiply connected areas was used an iteration algorithm [5,6].



a) b)

Fig. 2. a) temperature field of thermosyphon; b) distributing of temperature for ()

Evidently, gradients of temperatures in the direction of coordinate z do not exceed 12 K/m. In transversal direction temperature drops do not exceed 6 K.

The developed mathematical model differs from known by possibility of calculation of temperatures of surface of lower lid in any cross section. The last is important at analysis and estimation of limit thermal loadings on thermosyphons. Malfunctions of work are possible in conditions of overheat and subsequent complete drainage of surface of lower lid. The developed handling to analysis of thermal modes of thermosyphons allows calculating parameters of limit terms their work.

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