A STUDY CONCERNING THE CHARACTERISTIC
OF CAPILLARY-POROUS WICKS FOR
LOW-TEMPERATURE HEAT PIPES

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UDC 536.248.2:532.685

A method is described and results are shown of measuring the characteristics of capillary-
porous wicks for heat pipes on a single test stand.

Many studies have been made recently which show the effectiveness of using heat pipes as a solution
to various problems in heat transmission, thermostatization, thermal protection, etc., but nevertheless
there has been no reliable theory developed yet for the design of heat pipes. The description of heat and
mass transfer in some known theories is concerned mainly with the wick characteristics, which indicate
the limitations on the heat transmitting capability of a heat pipe.

Such characteristics of porous materials used for wicks are: a) the size (radius) distribution of
 pores: the integral \( w(r) \) and the differential \( dw/dr \), b) the total porosity \( \Pi \), c) the maximum height of feed
\( h_{\text{max}} \), d) the permeability as a function of the moisture content \( K(U) \), and e) the total permeability of a
specimen \( K \).

These characteristics are usually determined experimentally only, by means of various special test
devices.

Fig. 1. Schematic diagram of the electrical apparatus for
the capacitance method of measuring the moisture content
(I); moisture content in a wick as a function of the height,
at various instants of time (II).
In this article the authors outline a method of calculating the characteristics of capillary-porous wicks from the curves of feed kinetics which have been measured on a single test stand.

The feed kinetics in a capillary-porous wick will be understood here to mean the time variation of the longitudinal moisture-content profile in a wick \( U(h, t) \).

The feed kinetics are measured by various methods on the basis of: superhigh-frequency \( \gamma \)-radiation, change in the electrical resistance with changing moisture content, or change in the electrical capacitance with changing moisture content. Our procedure for determining the feed kinetics was based on the use of the electrical capacitance as the measure of the moisture-content field, analogous to the procedure in [1], but with the following modifications. It was not feasible to use two frequencies, because the rate of capillary feed action was especially high at the start. For this reason, the calibration curves were plotted not by calculation, as in [1], but experimentally, somewhat complicating the test series routine but also reducing the error. The calibration was done by drying a porous specimen.

The apparatus is shown schematically in Fig. 1, I. The moisture-content field in porous glass fiber was measured with 18 capacitors, with the specimen in a vertical position. The common plate of all capacitors was a metal cylinder on which glass fiber has been wound. Wire rings (1 mm thick) retaining the glass fiber served also as the second capacitor plates. Such a structure of a porous specimen is analogous to the structure of wicks used for heat pipes and, therefore, this is then a direct method of determining the characteristics of such wicks nondestructively.

The electric circuit (Fig. 1, I) contained capacitors \( C_1 \) and \( C_2 \), by which the uniformity of the electric field between the plates of each capacitor could be gaged. In order to eliminate the mutual interference between the fields of the capacitors, the high-frequency signal was sent sequentially to each capacitor alone through a stepper switch.

The method of calculating the characteristics of capillary-porous wicks for low-temperature heat pipes is illustrated on the feed kinetics of a grade ASST-b-2 wick (7 layers in 3 mm), measured as shown here.

The \( U(h, t) \) curves of feed kinetics for this wick have been plotted in Fig. 1, II.

From the curve which represents the moisture-content profile after the end of the feed process \( U(h)_{t=\infty} \) (Fig. 1, II), and by calculation according to the formula in [2]

\[
w = U \frac{\gamma_m}{\gamma_0} \tag{1}
\]

we obtain both the integral and the differential distribution of pores in the capillary-porous wick in a heat pipe (Fig. 2), and these yield the data about the minimum pore radius \( r_{\text{min}} = 28.4 \mu \), the mean or the predominant pore radius \( r_m = 30 \mu \), and the porosity \( \Pi = 53\% \).