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AN EXPERIMENTAL INVESTIGATION INTO THE EFFECT OF SURFACE THERMAL CONDUCTIVITY ON THE RATE OF HEAT TRANSFER IN DROPWISE CONDENSATION

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Abstract—The magnitude of the surface thermal conductivity effect in dropwise condensation heat transfer is determined experimentally in this work. The heat-transfer coefficient for a low conductivity surface (stainless steel) was measured using deposited thin-film resistance thermometers. Copper-surface data was obtained using a conventional test section. The results are in agreement with a previously developed analytical model.

NOMENCLATURE

h, overall dropwise condensation heat-transfer coefficient;
$\overline{h_d}$, dropwise condensation conductance for a surface with infinite lateral conductivity;
k, thermal conductivity;
q, heat flux;
$\hat{r}$, departing drop size;
ΔT, vapor-to-surface temperature difference.

1. INTRODUCTION

In a companion paper to the present work [1], the authors presented an analysis and proposed correlation for the dependence of the dropwise condensation heat-transfer coefficient on the thermal conductivity of the condensing surface material. The results agreed well with existing experimental data. Existing data for low conductivity materials, however, is subject to some doubt due to inherent inaccuracies in the conventional methods used to measure the condensing surface temperature. Hence, further experimental verification of the theory was desired.

The purpose of the present work is to examine critically the existing experimental data and to describe new experiments concerning the effect using a unique method of condensing surface temperature measurement: deposited thin-film resistance thermometers. It will be seen that the surface thermal conductivity effect predicted by the theory described in reference [1] is both qualitatively and quantitatively correct.

2. DISCUSSION OF PREVIOUS EXPERIMENTAL INVESTIGATIONS

Two distinct types of experiments demonstrating the existence of a surface thermal property effect on dropwise condensation heat transfer have been performed: direct measurements of the condensation film coefficient for different surface materials, and measurements of the temporal variation of the surface temperature during condensation. [The latter data are useful only in suggesting the presence of a thermal constriction resistance (surface thermal property effect) rather than giving quantitative information about it.] Investigations of both types will now be briefly discussed.

Perhaps the single most significant experimental difficulty in condensation heat-transfer research is due to the necessity of measuring accurately the temperature of the solid surface at which the phase change takes place. Since the surface conductances involved are very large, a slight error in the measurement of the fluid-to-surface temperature difference can lead to large errors in the computed heat-transfer coefficients. The problems are most acute when the thermal properties of the condensing surface are to be varied; low conductivity materials inherently lead to greater inaccuracies in almost any type of surface temperature measurement scheme.

By far the most popular scheme for ascertaining the surface temperature in condensation experiments has been the use of multiple interior thermocouples from which the temperature profile is extrapolated and the average surface temperature inferred. If a sufficient number of adequately spaced thermocouples are used in a high conductivity material, the method has been shown to be quite acceptable for obtaining the average surface temperature. However, as the thermal conductivity is decreased, the likelihood of significant error in this average value is substantially increased due to uncertainty in the location of the thermocouples within their holes [2].

Although most experimental studies on dropwise condensation have been performed using copper as a condensing surface material (due to its high conductivity and relative ease of promotion), at least four

Table 1. Previous investigations into the surface thermal conductivity effect in dropwise condensation

Investigator	Material	Thermal conductivity $\frac{W}{mK}$	Measured steamside coefficient ($W/m^2 K$)	Condenser orientation
Tanner et al [3]	Copper	381.	2.38×10^5	Vertical
	Stainless steel	17.3	0.45×10^5	Vertical
Griffith & Lee [4]	Copper	381.	0.57×10^5	Horizontal Facing Down
	Zinc	109.	0.26×10^5	
	Stainless steel	17.3	0.11×10^5	
Wilkins & Bromley [5]	Copper	393.	2.27×10^5	Condensation on Vertical tubes
	Gold	294.	1.99×10^5	
	Admiralty	121.	1.59×10^5	
	Cu-Ni 90-10	50.	1.25×10^5	
	Monel	27.	0.55×10^5	
Aksan & Rose [6]	Copper	381.	2.16×10^5	Vertical
	Steel	45.	2.38×10^5	Vertical
Present work	Copper	395.	1.50×10^5	Vertical
	Stainless steel	17.3	0.62×10^5	Vertical

investigators have produced relevant direct data on the surface thermal conductivity dependence of the dropwise condensation heat-transfer coefficient [3–6]. The data is summarized in Table 1.

In evaluating the results of these investigations, three main factors influencing the measurements must be considered: (1) the possible presence of significant noncondensable gas concentrations, (2) the accuracy with which the surface temperature was measured or inferred during condensation, and (3) the effects of surface chemistry differences due to differences in promoters and surface microproperties.

Tanner *et al.* [3] obtained values for the heat-transfer coefficient for atmospheric pressure dropwise condensation for both copper ($k \simeq 380\,W/mK$) and stainless steel ($k \simeq 17\,W/m \cdot K$) condensing specimens using the extrapolation method. The conductance for the stainless steel surface was found to be a factor of five lower than for the copper surface. The magnitude of the copper surface measurement was such that significant noncondensable gas effects were apparently not present; identical promotion and the absence of visual differences in the condensation on the two surfaces indicate that the large difference in the measured conductances could not be due to surface chemistry differences. The error in the wall temperature measurement as calculated by the Wilcox [2] method could have been as large as 0.5K at a heat flux of $3.2 \times 10^4\,W/m^2$ for this apparatus.

Griffith and Lee [4] measured heat-transfer coefficients for three different condensing surface materials with the condensing surface in the horizontal, face-down position. A modified extrapolation method was used, in which a thin condensing surface was soldered to a copper rod in which the temperature profile was measured. Conductances for stainless steel were again found to be a factor of five lower than those for copper. A uniform surface chemistry was obtained by standard promotion of the gold plated surfaces. Although noncondensable gases may have been present, the primary error in these data is thought to be due to extrapolation error (the solder-joint thermal resistance was not accounted for).

Recently, Wilkins and Bromley [5] investigated a whole series of condenser materials, measuring the overall coefficient of heat transfer between vapor and cooling water for thin- and thick-walled condenser tubes. The steamside coefficient was then inferred from the overall coefficient through knowledge of the coolant flowrate and material thermal conductivity. The results decrease systematically with conductivity with the conductance for Monel ($k \simeq 27\,W/m \cdot K$) reported to be a factor of four lower than that for copper. Noncondensable gases did not affect the apparatus, as indicated by the magnitude of the observed conductance on copper, but the surface chemistry was not controlled. Although conductivity-dependent errors could have been made in inferring the steamside coefficient, the systematic variation of the conductance with conductivity suggests that this was not the case.

Aksan and Rose [6] measured conductances on copper and copper-plated steel ($k \simeq 45\,W/m \cdot K$) using the extrapolation method, obtaining results in opposition to those previously described. In fact, the conductance they report for copper is somewhat lower than that for the copper-plated steel. The data were apparently flawed by neither noncondensable gas nor surface chemistry effects, but these authors estimated the possible error in their surface temperature measurements to be on the order of 0.6K. A rough calculation shows that if this error were indeed present, the data point for steel could easily have been a factor of two lower than the copper data point.* (Note that the steel used was rather more conductive than the stainless steels used in the other experiments; thus, the fact that the measured coefficient for steel could have been about half that for the copper is in substantial agreement with the other works.)

Aksan and Rose also argue that other measurements on PTFE-coated copper surfaces [7, 8] show no thermal constriction resistance effects, even though the thermal conductivity of PTFE is quite low. This points up an important idea—the thermal constriction resistance is dependent on thickness as well as conductivity. The measurements referred to had specimens with PTFE thicknesses of 0.0015 mm and 0.01 mm, respectively; significant constriction resistance can occur only for thicknesses two orders of magnitude larger. The fact that no constriction effect was observed is therefore not at all surprising.

Although the source of the thermal constriction resistance in dropwise condensation has been presented as arising from the nonuniformity of heat flux on the condensing surface, it should be apparent that this heat flux variation will result in a similar variation in temperature over the condensing surface. Since the drop distribution is nonsteady in the strict sense of the word, the temperature at a given point on the condensing surface will vary in time about the average surface temperature. If the actual surface temperature at a point were monitored, the existence of a time-varying surface temperature would be an indication of the existence of the thermal constriction resistance, although it is not clear if this temperature trace could provide quantitative information as to the magnitude of this resistance.

Numerous investigations have resulted in observations of fluctuating temperature signals from thermocouples located near the condensing surface [9–15]. An adequate discussion of all these works is impossible here; suffice it to say that even after extraneous sources of these signals (e.g. noncondensable gases) have been eliminated, temperature fluctuations of the expected amplitude and frequency occur.

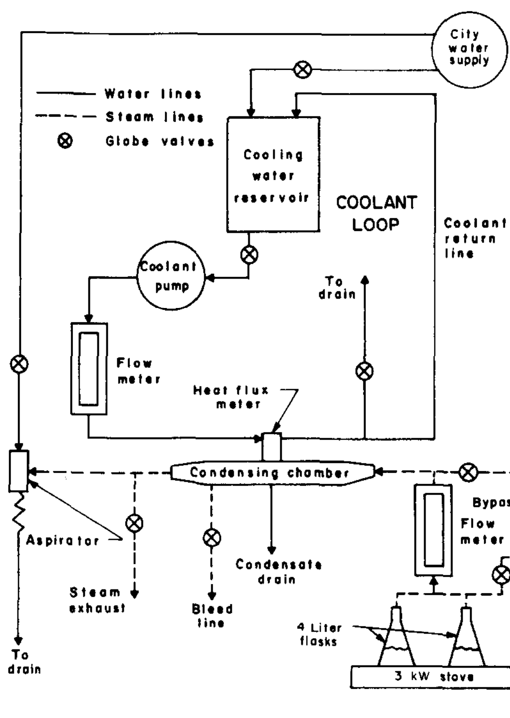
Consideration of the mass of experimental data described above leads to the conclusion that a significant surface thermal property effect in dropwise condensation indeed exists. However, the uncertainty in the quantitative values of the measured conductances on low-conductivity condensing surfaces calls for further experimentation using a more accurate surface temperature measurement scheme. The remainder of this paper describes just such an experimental investigation.

3. THE CONDENSATION RIG AND GENERAL EXPERIMENTAL PROCEDURES

Most dropwise condensation experiments may be broadly classified as being in one of two categories: first, those concerned with the *overall* thermal resistance from vapor to coolant, and secondly, those concerned with the direct measurement of the vapor-to-surface conductance (almost always employing the flat plate geometry). Although the vapor-side coefficient may sometimes be inferred in experiments of the former type, detailed information concerning the surface conductance is ideally obtained using the second approach.

In essence, the apparatus used in the present investigation consisted of an open-circuit vapor system by which steam is directed over the top surface of a cylindrical test specimen cooled on the opposite end by a separate, closed-circuit coolant loop. The steam flow was adjusted to combat the buildup of noncondensables near the surface without disturbing the condensate.

A schematic drawing of the apparatus is presented in Fig. 1. The flow-through steam system consisted of a steam generation and metering section, the condensing chamber, and a flow and static pressure control system. Two 4-l flasks heated by gas burners served as the boiler, which was charged with distilled water before each set of condensing runs. The steam was fed



STEAM SYSTEM

FIG. 1. Schematic drawing of test rig.

*It is important to realize that if the extrapolation method is used, statistical interpretation of the results can be made *only* if all thermocouples are removed and repositioned before each test. That is, the extrapolation error is due to the uncertainty in the position of each thermocouple in its hole; if they are not disturbed, the scatter in the resulting measurements will be due to sources other than extrapolation, with the governing extrapolation error remaining constant. This is why the extrapolation method is inherently unsuited for measurements in low conductivity materials; measurements taken without repeated thermocouple repositioning do not represent true mean values.

to a calibrated flowmeter for monitoring of steam velocity; a bypass system was provided to eliminate premature condensation in the meter during actual heat transfer data taking.

The 5.08 × 5.08 cm brass condensing chamber was designed expressly to minimize noncondensable gas effects through proper flow development and the elimination of abrupt changes in cross-section, protuberances, or sharp corners which could trap noncondensables [16]. Taps for vapor temperature and static pressure (measured with a water U-tube manometer) were provided, and opposite the condensing surface a window was fitted to allow visual or photographic observation of the condensing process. A steam bleed valve and condensate drain were also provided.

For all condensation rates employed, at least 60% of the steam passing by the test surface was not condensed. The steam velocity in all tests was monitored and maintained within 10% of 0.38 m/s past the condensing surface. To insure that significant amounts of noncondensable gases did not enter the steam system through leaks, system pressures slightly higher than atmospheric were employed. This was accomplished by using an aspirator pump in which tap water at high velocity passes an orifice through which steam from the condensing chamber flows and is subsequently condensed in the flowing water. Observed steam saturation temperatures were in the range 100.56–101.67°C.

Water was used as the cooling fluid in the closed-circuit coolant loop. The water was circulated by a pump at up to 0.63 l/s from either a 114 l drum with built-in chiller (allowing coolant temperatures near 0°C) or a 227 l reservoir. Before passing through the rear of the test sections, the coolant flow was measured by a calibrated flow meter. The loop was closed by a coolant return line feeding the coolant reservoir.

In order to obtain a standard surface chemistry for all runs, the gold surfaces used were promoted in the following manner: a 1% solution of di-*n*-octadecyl disulfide in CCl_4 was first prepared; then 4 ml of this solution was added to each almost-full four liter boiler flask, previously filled with triple-distilled water. The dropwise condensation so obtained was of excellent quality.

Before any given set of runs, the system was operated without taking data (no coolant flow) to boil off excess noncondensables in the water. A given steady state steam condition was then obtained; either ice water or tepid water was used as the coolant, at various flow-rates, to obtain different heat fluxes. One-half hour was allowed between runs to ensure that the system was indeed operating at a steady state.

Chromel–Alumel (ASTM Type K) couples 0.008 mm in diameter with PTFE insulation were used for both vapor temperature and heat flux measurements. The vapor thermocouples were inserted in closed glass tubes sealed with silicone rubber and immersed in the vapor through ports in the condensing chamber. The heat flux was measured by utilizing thermocouples in 0.71 mm dia wells located along the axis of the test sections; Fourier's law was invoked by fitting a straight line to the resulting temperature-position data. The thermocouple hole positions were determined to 0.0025 mm through the use of a travelling microscope. The linearity of the thermal profiles obtained was excellent; the R.M.S. deviation from the fitted straight lines was about 0.11°C.

The couples were connected to a Leeds and Northrup precision rotary thermocouple switch and thence to reference junctions in a carefully prepared ice-point cell. Thermocouple voltage detection was accomplished through the use of a Leeds and Northrup K4 potentiometer with external galvanometer.

4. CONDENSATION EXPERIMENTS ON STAINLESS STEEL

The primary thrust of the investigation was toward the accurate measurement of the condensation heat-transfer coefficient on a low-conductivity material, but it was also necessary to verify that "normal" values of the heat-transfer coefficient could be obtained on a copper surface under identical condensation conditions. Different methods were employed to determine the condensing surface temperature for stainless steel and copper; the overall test section configuration for the two also differed slightly.

For the stainless steel measurements, the test section consisted of two parts: an instrumented test disc held in place by a wall support plate and plastic retainer, and a cooled copper rod in which the heat flux was measured via Fourier's law. A schematic drawing of the arrangement is presented in Fig. 2.

The heat flux meter, a section of copper rod with thermocouples mounted along its axis and through which the coolant flow passed, was forced against the back of the disc by a pressure system consisting of a pressure plate and four adjusting bolts. Alignment was facilitated by a plastic slug holding ring. The discs and the heat flux meter were lapped to achieve flatness, and thermal heat sink grease was used to lower the thermal contact resistance.

Sealing was provided by an O-ring between the disc retainer and the wall support plate (the latter being soldered to the brass condensing chamber), and also by an O-ring sandwiched between the test disc and the slug holding ring.

Unique to the present investigation was the method of obtaining the surface temperature during condensation on the stainless steel disc. A thin-film device was developed which accurately measured the condensing surface temperature without disturbing the fluid mechanics or heat transfer of the dropwise condensation process; further, the serious limitations inherent in the extrapolation method for low conductivity materials were avoided.

This thin film resistance thermometer is shown in Fig. 3(a) and (b). The top surface of a stainless steel disc was first coated with a thin (0.001 mm) electrically insulating layer of (tri)silicon (tetra)nitride (Si_3N_4) using an evaporative process. Next the surface was coated with a layer of titanium, which was then "pattern generated" using a photographic selective etching process to obtain the meander resistor configuration

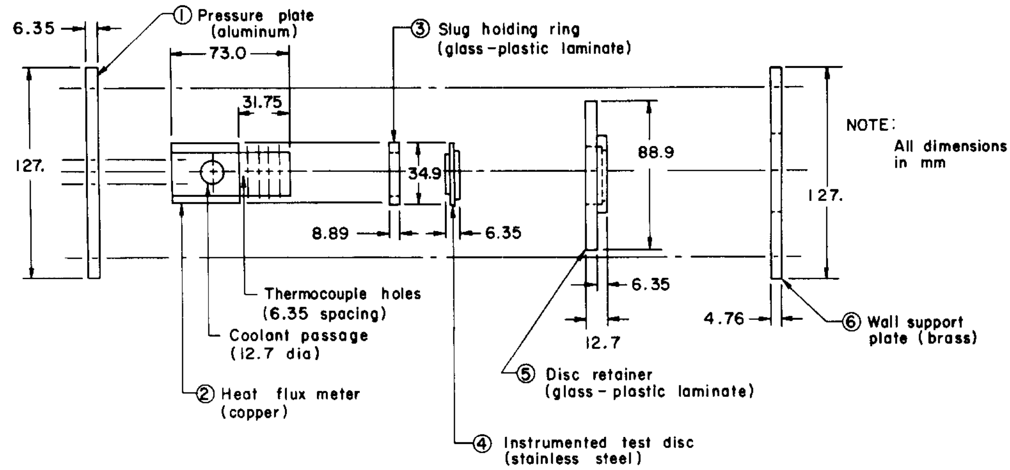


FIG. 2. Stainless steel condenser test section.

depicted in Fig. 3. Titanium was used as the temperature sensing element by virtue of its relatively high temperature coefficient of resistance.

Next, most of the face of the disc was covered with another layer of Si_3N_4, leaving the terminals exposed for electrical connection. This layer served as electrical insulation for the resistance thermometer, since a final layer of gold was necessary to support the actual dropwise condensation with a uniform, standard surface chemistry.

Figure 3(b) is a cross-section through the disc showing the various layers involved and their respective thicknesses. As an illustration of the efficacy of thin-film thermometry in the measurement of surface temperature, the thermal resistances imposed by the various layers are shown in Table 2. It is seen that the total conductance for the four layers that make up the thin-film thermometer is about 4.8×10^6 W/m^2 K. This means that the total thermal resistance imposed by the measuring device is only about 2% as large as the surface thermal resistance in dropwise condensation. Further, at a heat flux of 1.6×10^5 W/m^2, the temperature drop through the top layers (Au and Si_3N_4) is only 0.03K. Therefore, it may be concluded that the thin-film resistance thermometer accurately recorded the condensing surface temperature; the meandering path of the resistor insured that the temperature recorded was the surface average.

Lead attachment to the thin-film resistor was accomplished in the following manner. The completed discs were mounted in a laminated plastic holder designed so that on final mounting in the steam chamber, the face of the disc would be flush with the steam chamber walls. Holes were drilled at the edge and segments of 1.0 mm dia copper wire were epoxied in place so that the wire extended short distances on either side of the plastic holder, Fig. 4. Fine gold wires (0.125 mm in dia) were soldered to the copper "posts"; the free end was then attached to the thin film resistor terminals using a conductive epoxy. Exposed wiring was then coated with a high temperature, water resistant cement for electrical insulation.

In order to monitor the resistance of the transducer, and thus the condensing surface temperature, a precision DC Wheatstone Bridge (Leeds and Northrup Model 4289) was used. The accuracy of this bridge is about 0.1%; after calibration of the sensors, this resulted in a vapor-to-surface temperature difference accuracy

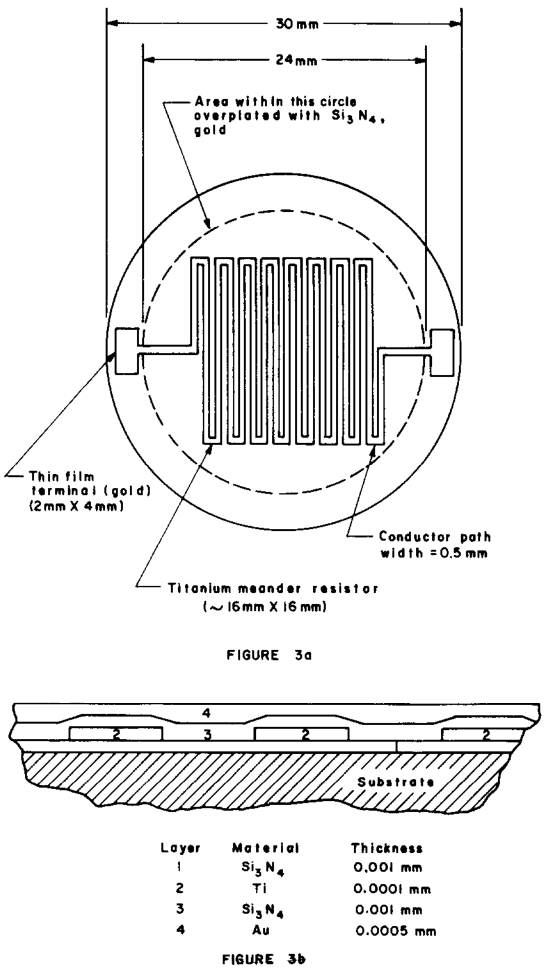


FIG. 3. Schematic drawings of thin-film meander thermometer.

Table 2. Thin-film thermal resistances

Layer	Material	Thickness (mm)	Conductivity (W/m K)	Resistance $(W/m^2 K)^{-1}$	Conductance $(W/m^2 K)$
1	Si_3N_4	0.001	10.0	1.0×10^{-7}	9.99×10^6
2	Ti	0.0001	20.8	0.048×10^{-7}	2.08×10^8
3	Si_3N_4	0.001	10.0	1.0×10^{-7}	9.99×10^6
4	Au	0.0005	312.	0.016×10^{-7}	6.24×10^8

Overall conductance $h = \left(\Sigma\left(\frac{1}{h}\right)\right)^{-1} = 4.8 \times 10^6 \ \frac{W}{m^2 K}$

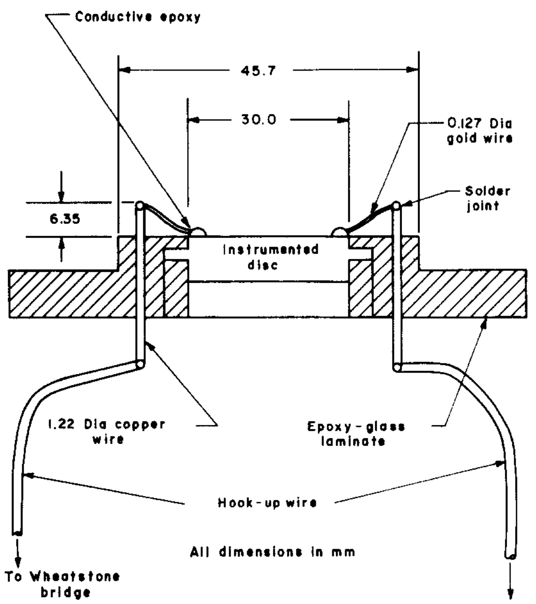


FIG. 4. Lead arrangement for test discs.

of about ± 0.3 K, independent of heat flux. The stainless steel heat-transfer coefficient data of the present work is thought to be the most accurate thus far obtained.

Calibration of the thin-film resistance thermometers was accomplished by insulating the stainless steel disc (with the heat flux meter removed) to prevent heat flow through it. Steam was then admitted to the steam chamber and the system allowed to come to thermal equilibrium. The resistance of the thermometers was then recorded along with the steam chamber temperature as measured by the two vapor thermocouples. By varying the pressure within the steam chamber, a range of temperature calibration points was obtained to allow a least-squares data fit and the construction of a calibration curve of surface temperature versus sensor resistance.

It should be noted that the method of calibration used minimized possible errors in the measurement of the quantity of interest, the vapor-to-surface temperature difference. Since the calibration of the surface thermometers was accomplished using the vapor thermocouples actually used in the condensation experiments, any absolute errors in the calibration of these thermocouples did not affect the results.

During the course of the stainless steel surface condensation experiments, two different discs were employed. Due to the high thermal resistance imposed by the stainless steel disc and the thermal contact resistance between this disc and the copper heat flux meter, the heat fluxes obtainable were limited to the range 0.063–0.174 MW/m^2. The heat-transfer coefficient in dropwise condensation increases with heat flux for low values of the heat flux. The heat fluxes used in the present tests were high enough to produce dropwise condensation conductances essentially independent of heat flux.

Heat transfer coefficient data obtained using the two stainless steel sensors over a period of weeks is shown in Fig. 5. Here the vapor-to-surface temperature difference is plotted vs heat flux. Since the heat-transfer coefficient is almost independent of the heat flux for the range of heat fluxes studied, the slope of a straight line fitted to these data points will give the average heat-

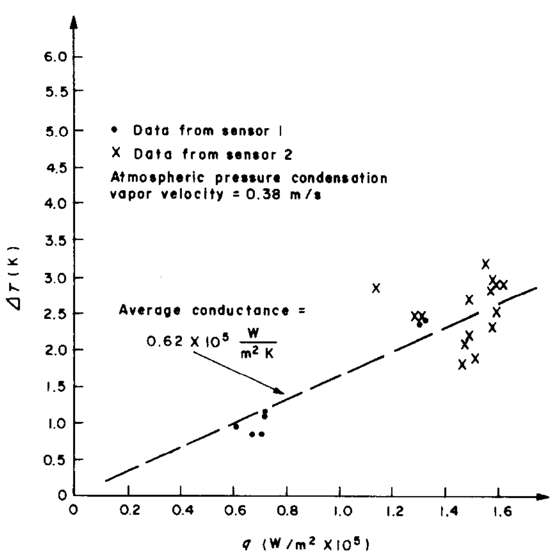


FIG. 5. Temperature difference vs heat flux for dropwise condensation on stainless steel.

transfer coefficient measured for the stainless steel. This mean heat transfer coefficient is 61 900 W/m^2 K. Since the expected R.M.S. error in the measured surface-to-vapor temperature difference is about 0.3K, it can be seen that the data are very well behaved; roughly three-quarters of the data points lie within a band $\pm$0.3K from the line shown in Fig. 5.

5. CONDENSATION EXPERIMENTS ON COPPER

Initially, attempts were made to obtain thin-film resistance elements on copper discs, but these efforts failed due to the reactive nature of copper under conditions required for the film deposition. The decision was made to obtain the copper data using a conventional test section, since quite accurate results can be

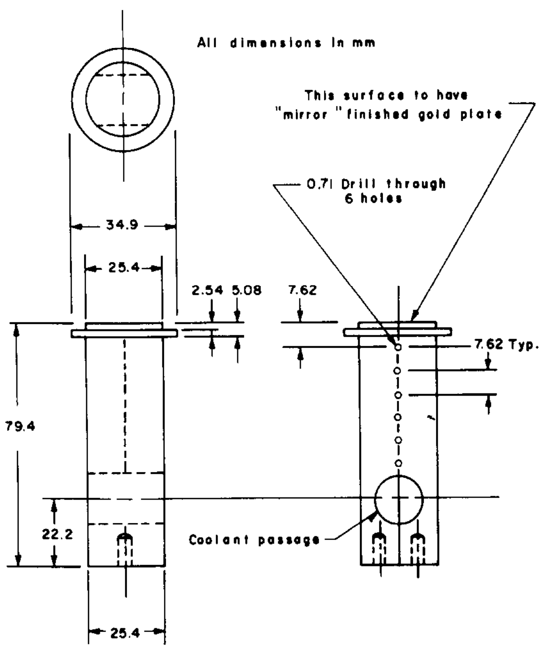


FIG. 6. Conventional copper test section.

obtained via the extrapolation method with this high conductivity metal. In fact, the extrapolation error for the test section finally used, calculated by the method of Wilcox, was only 0.07K for a heat flux of 1.57 $\times$ 10^5 W/m^2, substantially lower than the errors involved with the stainless steel resistance thermometers.

In order to obtain a uniform surface chemistry for all experiments, the copper test section used (Fig. 6) was polished and plated with 0.003 mm of gold. Thus, for both the stainless steel and the copper test sections, a mirror-smooth gold surface supported the dropwise condensation; any differences in the conductances measured could be attributed only to differences in surface thermal conductivity.

The design of the test section, which featured six axial thermocouple locations, made it easily interchangeable with the composite stainless steel test section; no modifications to the condensing chamber were required.

The condensation data, obtained on six different days, is shown in Fig. 7. Care was taken in all runs to create test conditions identical to those of the stainless

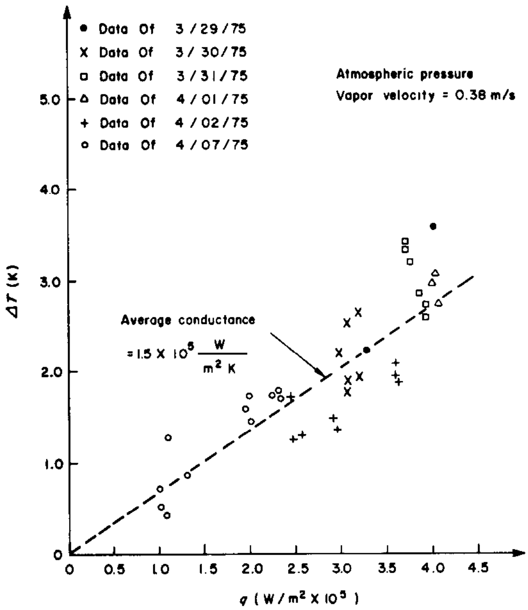


FIG. 7. Temperature difference vs heat flux for dropwise condensation on copper.

steel runs. The mean heat-transfer coefficient obtained for the copper condensing surface was 1.5 $\times$ 10^5 W/m^2 K, almost 2.5 times as large as the coefficients measured for the stainless steel surfaces.

It will be noted that the copper surface heat-transfer coefficient measured in this investigation was somewhat lower than that obtained by some other investigators for copper surfaces. This is thought to be a surface chemistry effect, attributable to two factors: (1) the surface, in the present work, was mirror-smooth gold promoted via the steam supply, as opposed to the normal copper surface promoted directly, and (2) since the promoter was added to the steam supply, a buildup of the chemical used could have occurred in the piping, even though the boiler flasks were periodically cleansed. Thus, an excess of promoter could have been present on the surfaces under test. However, it is important to emphasize that the surface chemistry was identical for both types of test section used, and that the strong conductivity dependence of the steamside coefficient noted by previous investigators has been verified.

6. COMPARISON OF EXPERIMENTAL RESULTS TO THEORY

The theory developed earlier [1], which was shown to correlate well with previously obtained experimental data, predicts the thermal constriction conductance for a given fluid condensing in the dropwise manner on a surface of thermal conductivity k as a function of the departing drop size $\hat{r}$ and the heat-transfer coefficient for a surface with infinite lateral conductivity, $\overline{h_d}$.

In order to ascertain the departing drop size in the present experiments, twenty low magnification photographs (nominally 5 $\times$) were taken during condensation at both high (1.74 $\times$ 10^5 W/m^2) and low (0.63 $\times$ 10^5 W/m^2) heat fluxes. The photographs were obtained with the camera aimed at the central portion of the

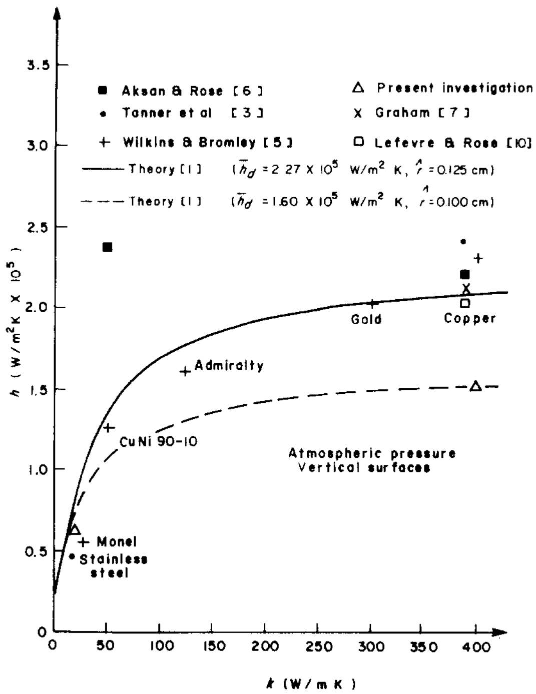


FIG. 8. Comparison of experimental data to theory —dropwise condensation conductance vs surface thermal conductivity.

condensation surface. Examination of the photographs revealed a maximum droplet radius of 1.0 mm.

From the magnitude of the measured copper surface conductance, an estimate of the asymptotic conductance $\bar{h}_d$ for the present experiments was made of 1.6×10^5 W/m^2 K. Using the correlation developed in [1], the overall dropwise condensation heat-transfer coefficient was calculated as a function of surface thermal conductivity; that is shown as the dotted line in Fig. 8. It can be seen that the theory is in excellent agreement with the obtained experimental results.

Also shown in Fig. 8, for comparison, are the results of previous investigations as compared to the theory.

7. CONCLUSION

Experimental verification of the magnitude of the surface thermal conductivity effect in dropwise condensation heat transfer has been provided by the experiments described herein.

Dropwise condensation heat-transfer coefficient measurements for a gold-coated stainless steel surface were accomplished through the use of deposited thin-film resistance thermometers, yielding a mean heat-transfer coefficient of 0.62×10^5 W/m^2 K. This low conductivity data is thought to be the most accurate obtained to date.

A conventional gold-coated copper test section was employed to obtain comparative data. Under identical condensing conditions, the copper-surface heat-transfer coefficient was found to be 1.5×10^5 W/m^2 K, almost 2.5 times the value obtained for stainless steel.

The data was shown to agree with the theoretical treatment developed previously.

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ETUDE EXPERIMENTALE SUR L'INFLUENCE DE LA CONDUCTIVITE THERMIQUE DE PAROI SUR LE TRANSFERT DE CHALEUR PAR CONDENSATION EN GOUTTES

Résumé—Dans la présente étude on détermine expérimentalement l'importance de l'influence de la conductivité thermique de la paroi sur le transfert de chaleur par condensation en gouttes. Le coefficient de transfert de chaleur dans le cas d'une surface de faible conductivité (acier inoxydable) a été mesuré à l'aide de thermomètres à résistance déposée en film mince. Les données relatives à une surface de cuivre ont été obtenues sur une section d'essai conventionnelle. Les résultats sont en accord avec un modèle analytique développé antérieurement.

EINE EXPERIMENTELLE UNTERSUCHUNG FÜR DEN EINFLUSS DER WÄRMELEITFÄHIGKEIT EINES KÜHLKÖRPERS AUF DEN WÄRMEÜBERGANG BEI TROPFENKONDENSATION

Zusammenfassung—In dieser Arbeit wird experimentell der Einfluß der Wärmeleitfähigkeit des Kühlkörpers auf den Wärmeübergang bei Tropfenkondensation bestimmt. Der Wärmeübergangskoeffizient für eine schlecht leitende Oberfläche (legierter Stahl) wurde mit Hilfe eines Dünnfilm-Widerstandsthermometers gemessen. Ergebnisse für eine Kupferoberfläche wurden mit einem konventionellen Versuchskörper erhalten. Die Ergebnisse stimmen mit einem vorher entwickelten analytischen Modell überein.

ЭКСПЕРИМЕНТАЛЬНОЕ ОПРЕДЕЛЕНИЕ ВЛИЯНИЯ КОЭФФИЦИЕНТА ТЕПЛОПРОВОДНОСТИ МАТЕРИАЛА ПОВЕРХНОСТИ НА ИНТЕНСИВНОСТЬ ТЕПЛООБМЕНА ПРИ КАПЕЛЬНОЙ КОНДЕНСАЦИИ

Аннотация — В данной статье проведено экспериментальное изучение влияния величины коэффициента теплопроводности материала поверхности на теплообмен при капельной конденсации. Коэффициент теплообмена для поверхности (нержавеющая сталь) с малой проводимостью измерялся с помощью напыленных тонкопленочных термометров сопротивления. Получены данные для медной поверхности. Результаты согласуются с ранее разработанной аналитической моделью.