Int. J. Heat Mass Transfer. Vol. 24, No. 9, pp. 1554–1555, 1981.
Printed in Great Britain

0017 9310/81/091554 02 $02.00/0

ADDITIONAL PARAMETERS IN TWO-PHASE CLOSED THERMOSYPHONS: EFFECTS OF TUBE DIAMETER AND WALL THICKNESS

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(*Received* 11 *November* 1980 *and in revised form* 24 *March* 1981)

NOMENCLATURE

- d, diameter of tube, inside;
- L, length of tube;
- L^+, length ratio, L_h/L_c;
- Pr, Prandtl number, flowstreams;
- Re, Reynolds number, flowstreams;
- Re^*, Reynolds number ratio, Re_h/Re_c;
- T, temperature;
- t, wall thickness;
- U, overall heat transfer coefficient of an exchanger.

Subscripts

- c, cold stream; condenser side;
- h, hot stream; evaporator side;
- in, inlet;
- r, reference.

THE USE of heat pipes and two-phase closed thermosyphons in a heat recovery system in many industrial practices is extremely attractive because it allows for the transfer of a large amount of heat through relatively small surface areas without moving parts. An example of its application is to keep permafrost frozen as a structural foundation in cold regions such as used in Alaska pipelines [1].

In previous studies [2, 3], we have studied, both analytically and experimentally, the effects of various parameters, such as Reynolds and Prandtl numbers of both hot and cold fluid streams, heated to cooled length ratio, Reynolds number ratio, etc. on the performance of a heat exchanger using two-phase closed thermosyphons with no outer fins (called here 'bare') as the heat transfer elements. The effects of the tube diameter and wall thickness on the overall heat transfer coefficient of a 'bare' thermosyphon, however, were never investigated.

The local boiling and condensing coefficients of a 'bare' thermosyphon were studied experimentally by Larkin [4]. While Larkin's condensing coefficient seemed to be affected by the tube diameter, the boiling heat transfer coefficient seemed to be affected less. Japiske in his extensive review [5] concluded that no systematic study based on L/d and d with regard to the thermosyphon was available in the literature.

Recently, the authors developed an extensive computer program to determine the characteristics of heat exchangers using either 'bare' or 'finned' two-phase closed thermosyphons [6]. The analysis used in the program is based on the thermal resistance network that is already reported in [3], but has been modified to accommodate the 'finned' thermosyphons.

Keeping the ratio of L/d constant, the value of the tube diameter was changed to see the effect of the diameter for the conditions described in Fig. 1. The results as shown in Fig. 1

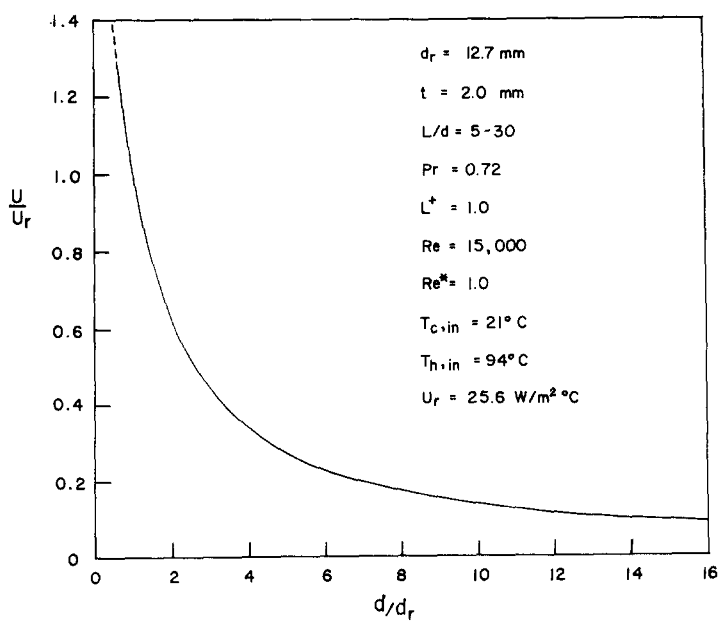

FIG. 1. Effect of diameter.

illustrate that the overall heat transfer coefficient is strongly affected by the value of the tube diameter. The effect of the ratio L/d, however, seems to be negligible for the range of L/d investigated. The decrease of the overall heat transfer coefficient with increasing tube diameter is mainly brought about by changes in the thermal resistances of convective and evaporation regions. As expected, the tube wall thickness has little effect.

It is concluded that the effect of the tube diameter on the performance of heat exchangers using 'bare' two-phase closed thermosyphons as heat transfer elements is very significant, especially when the tube diameter is less than about 8 cm.

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