NASA TECH BRIEF

Performance Map of a Heat Pipe Charged with Ammonia

Ammonia and water were compared as working fluids in heat pipes of type-304 stainless steel; a performance map for ammonia is presented. Each pipe measured 15.5 in. (length) by 0.44 in. (outer diameter) by 0.020 in. (wall thickness), and had a wick of two-layer 100-mesh screen lining the interior. Two flow-through calorimeter-type heat exchangers, using water, served as a heat source for the evaporator and as a heat sink for the condenser

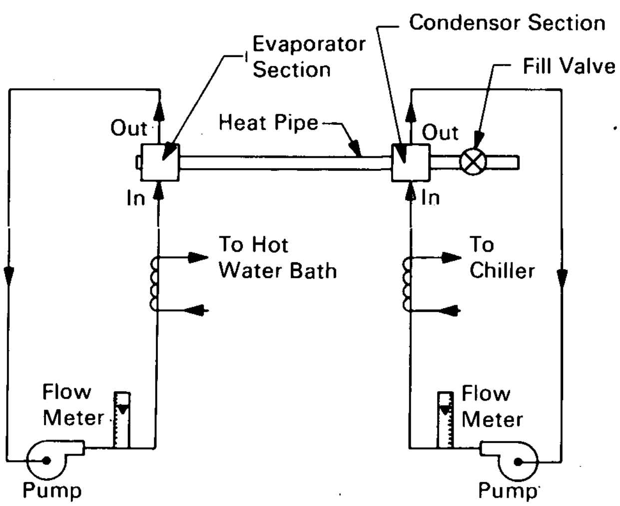

Figure 1. Apparatur Schematic

(Fig. 1). Heat input to the pipe ranged from 5 to 60 W; "dryout" began at the higher power. The condenser loop was fed from a reservoir chilled to a constant temperature.

The heat pipe is a self-contained engineering structure with a thermal conductance which exceeds the capability of a homogeneous piece of any known metal. Conductance proceeds by evaporation of a liquid within one part of a container (one end of a tube), transfer of the vapor to another part of the container, condensation of the vapor, and return of the condensate to the evaporator through a suitable capillary wick.

A performance map is useful, during preliminary design evaluation, for predicting heat pipe capability; it is especially useful for comparing pipes of varying dimensions and working fluids.

In the tests with ammonia, two phenomena were associated with dryout. First, the quasi-equilibrium state occurred at the onset of dryout, when one part of the evaporation section rose much higher in temperature than the rest of the section. This condition prevailed for as long as 1 hr, even though the thermal input continually increased. Some time later, the entire section rose in temperature, and "burnout" resulted. Second, the dryout front advanced along the evaporation section, beginning farthest from the condenser. At the onset of burnout, this front moved in steps toward the adiabatic section.

The lower the temperature of the condenser sink, the greater the heat transfer by the pipe, but the lower its operating (vapor) temperature at dryout. At operating temperatures below about 90°F, ammonia transfers up to three times as much heat as does water. At higher temperatures, however, water's advantage increases to 30% at the onset of dryout (Fig. 2). The relative performances of ammonia and water indicate that the figure of merit (for vapor as well as for liquid) is a fairly accurate basis for preliminary performance evaluation.

The temperature drop across the container and saturated wick was slightly higher for water than for ammonia; but the curves differ little in slope below the onset of dryout of the ammonia heat pipe,

(continued overleaf)

which was under a smaller heat load than was the water pipe.

The effective thermal conductance of liquid ammonia was lower by a factor of 7 than that of

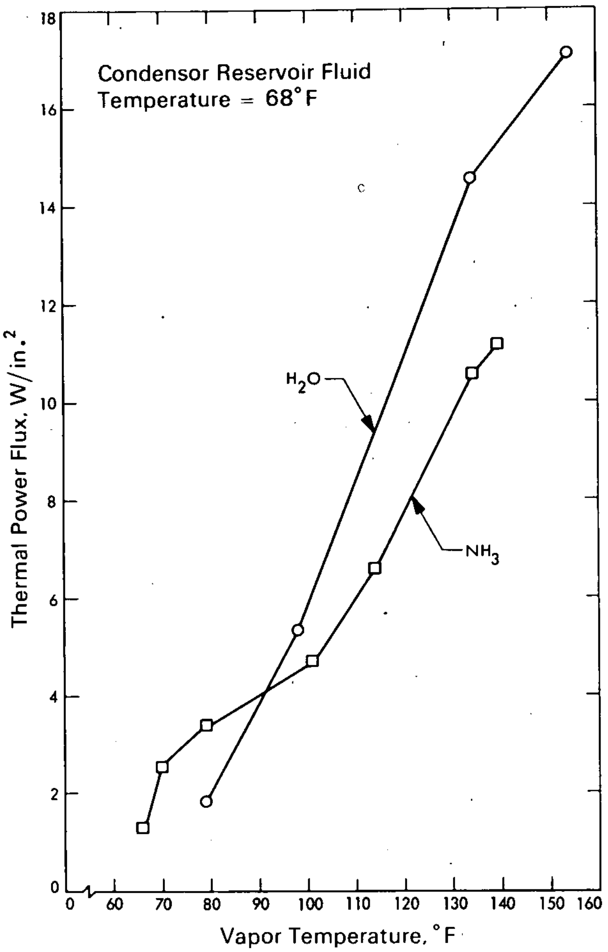

Figure 2. Transport of Heat by Two Working Fluids

the ammonia-saturated wick. The water-saturated wick's conductance, however, was only half that of the ammonia-saturated wick. This fact reflects the relatively higher vapor pressure of ammonia, which caused the meniscus to recede much further into the ammonia-saturated wick than in the water-saturated wick. Thus, in the former, there was a thinner layer of liquid and a shorter thermal path than in the latter.

The vapor mass-flow rates in both pipes were linear functions of heat load. The rate in the ammonia pipe was twice that in the water pipe because of ammonia's lower heat of vaporization.

The difference in density between the two vapors made the velocity of the ammonia vapor through the vapor core lower by about three orders of magnitude than that of the water vapor.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)
   Reference: N65-20720, Theory of Heat Pipes.

2. Technical questions may be directed to:
   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: TSP70-10726

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

Patent Counsel
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