NASA TECH BRIEF
Ames Research Center

Restartable Heat Pipe

The problem:

To design a heat pipe which readily starts operating after it has been cooled to or below the freezing point of its working fluid.

The solution:

A heat pipe which includes a second, low freezing point fluid in addition to its normal working fluid.

How it's done:

A heat pipe consists of a closed container (usually in the shape of a pipe) with all interior surfaces lined with a capillary structure such as a wick. The wick is soaked with a fluid, and only the vapor of the fluid is present in the free space within the pipe. When heat is applied to a given area of the heat pipe, a portion of the fluid in the wick in the warm zone evaporates and locally increases the pressure of the fluid's vapor; the vapor then flows to cooler portions of the pipe where it gives off heat as it condenses and eventually is returned by wicking action to the warmer zone. Thus, a heat pipe transfers heat from a warm zone to a cool zone some distance away. If the working fluid freezes in the cold zone, it is not returned to the warm zone and the transfer of heat stops, because the wick in the warm zone becomes dry.

In order to maintain a heat pipe operative when the working fluid has been frozen in the cold zone, a heat pipe of standard configuration is constructed with two working fluids, a main working fluid and a small amount of an auxiliary working fluid. The main working fluid has the efficient heat-transfer properties and physical characteristics of the fluids commonly employed in heat pipes, and the auxiliary working fluid is not quite as effective as a heat-transfer medium but it does have a considerably lower freezing point than the main working fluid. Thus, should the entire quantity of the efficient working fluid be frozen solid in the cold end of the heat pipe, the auxiliary working fluid will transfer heat to the cold end until the main working fluid becomes operative and essentially takes over the heat transfer functions of the heat pipe.

The heat transfer function can be accomplished by using two heat pipes containing working fluids with different freezing points. The auxiliary, low freezing point fluid heat pipe is arranged to supply heat and to melt the fluid in the wick of the primary heat pipe, which uses a high-efficiency, high-freezing point working fluid. Alternatively, both fluids can be contained in a single cavity and advantage taken of wicking action control by appropriate selection of working fluids and wick material. Many materials (e.g., copper) will be wetted by methyl alcohol but not by water; oxidized copper will be wetted by both fluids. Thus, a heat pipe equipped with alternating strips of copper mesh and oxidized copper mesh could take advantage of this selectivity of materials toward certain liquids.

When integrated into a heat pipe, the metallic copper mesh would tend to reject water droplets formed on it and will, therefore, not be soaked with water when both water and the freezing point depressant (methyl alcohol) condense out of a mixture of both vapors. It will, however, be soaked with methyl alcohol. Should the wick temperature drop below the freezing point, only the oxidized part of the copper mesh, which is soaked with water, would freeze. When water has been entirely removed from

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the warm end as a result of freezing at the cold end, the strip of wick material wetted only by the depressant will remain active. As the heat load is increased, enough heat transfer is provided to melt the water in the heat pipe and allow it to function.

Note:

No additional documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer
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Reference: B72-10188

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457(f)] to the TRW Systems Group, TRW, Inc., One Space Park, Redondo Beach, California.

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