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Promotion of Dropwise Condensation of Ethyl Alcohol, Methyl Alcohol, and Acetone by Polytetrafluorethylene

At NASA Langley it has been shown that dropwise condensation of polar organic vapors can in some cases be achieved by coating the condensing surface with a thin layer of teflon (which is nonpolar).

Condensation of a vapor on a surface is characterized by either of two mechanisms: filmwise or dropwise condensation. The phenomenon of dropwise condensation, in which the condensate forms into drops rather than covering the entire cooling surface with a continuous film, produces heat-transfer coefficients as much as 2 to 10 times greater than those produced filmwise condensation. Promotion of dropwise condensation is therefore desirable for increasing the effectiveness of condensing systems.

When a surface at a temperature below the saturation temperature of a vapor is exposed to that vapor, either saturated or superheated, liquid condensate forms on the surface. If the liquid wets the surface, it spreads out and establishes a stable film; consequently, the process is called filmwise condensation. Further vapor condenses on the liquid at the interface because of the heat transferred through the liquid film. With pure saturated vapor, the temperature at the liquid-vapor interface is also essentially the saturation temperature.

If the liquid does not wet the surface, droplets form and run down the surface, coalescing as they travel downward because of gravity forces. Little is understood about the mechanism of dropwise condensation or the associated heat-transfer process, except that heat-transfer rates are from 2 to 10 times those for filmwise condensation at the same temperature difference. Commercially, it is difficult to predict whether dropwise condensation will occur and difficult to maintain it for long periods of time. No known ordinary metallic surface, when clean, will produce dropwise condensation. To obtain dropwise condensation, metallic surfaces must be coated with a

film of some substance that the liquid does not wet, or a suitable promoter may be injected into the condenser with the incoming vapor. Some promoters of dropwise condensation are the fatty acids, mercaptans, light hydrocarbon oils, and waxes. However, promoters of this type wash off the condensing surfaces rather quickly and usually last only for periods of several seconds or, in some rare cases, up to a maximum of several hundred hours.

The increased heat-transfer rate achievable with dropwise condensation is desirable in the design of commercial condensing equipment. However, because of the difficulty in predicting and maintaining dropwise condensation, such equipment is presently designed on the assumption that filmwise condensation will exist. Improvements in prediction techniques and development of a permanent promoter which may permit the design of condensers based on the occurrence of dropwise condensation are therefore highly desirable.

In the experimental program performed at NASA Langley, promotion of dropwise condensation of several organic vapors was achieved by coating a bare iron tube with polytetrafluoroethylene (Teflon). The overall heat-transfer coefficients during dropwise condensation are approximately 30 percent greater for ethyl alcohol, 45 percent greater for methyl alcohol, and 65 percent greater for acetone than those during filmwise condensation.

Results from this investigation along with a study of previously reported experimental results show that the type of condensation which occurs from organic vapors on teflon condensing surfaces may depend on the dipole moment of the organic molecule. Nonpolar organic vapors tend to condense filmwise whereas vapors with a strong dipole moment tend to condense dropwise.

(continued overleaf)

Note:

Requests for further information may be directed to:
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No patent action is contemplated by NASA.

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