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NASA TECH BRIEF

Lewis Research Center

Submerged Gas Injector Expels Cryogenic Liquids from Tanks

The amount of pressurizing gas required to expel a cryogenic liquid from a tank can be reduced by vaporizing a small portion of the cryogenic liquid into the pressurizing gas. It is often desirable to accomplish this while using a cold pressurizing gas at the cryogenic liquid temperature and without heating the bulk liquid in the tank.

The principle has been successfully demonstrated by injecting helium gas through a submerged porous flat plate directly into liquid hydrogen, rather than by admitting the helium into the vapor space (ullage) above the liquid. As the helium bubbles up through the liquid hydrogen, the hydrogen vaporizes and diffuses into the helium bubbles. The bubbles become saturated with hydrogen gas and are carried into the ullage volume, where the partial pressures of the helium and hydrogen vapors add to the total expulsion pressure. Since the helium is injected at the temperature of the liquid hydrogen and no external heat is applied, all of the heat of vaporization comes from the bulk liquid.

For a specific application, the helium is stored as a pressurization gas at the temperature of liquid hydrogen in order to minimize the volume and weight of the helium storage tanks. Heating the gas reduces the amount of helium required for pressurization, but adds the weight and complexity of heating equipment. Experiments have shown that the weight of helium required for the submerged-injector method, using cold helium at liquid hydrogen temperature, is approximately the same as that required for a warm-gas system at a tank pressure of 130.9 kN/m^2 (19 psia). This weight is approximately one-fourth of that required to pressurize with cold helium admitted above the liquid.

Notes:

1. Other means could also be used to vaporize cryogenic liquid into the pressurizing gas. For example, the conventional diffusion nozzle used to admit pressurizing gas above the liquid could be replaced by a venturi nozzle with a dip tube extending from the low-pressure region in the nozzle throat into the bulk liquid. In the nozzle throat, the liquid drawn up through the dip tube would vaporize and mix with the pressurizing gas.
2. The principle of the submerged gas injector could also be adapted for subcooling the cryogenic liquid, since the heat of vaporization comes from the liquid.
3. This innovation is in the conceptual stage only, and, as of the date of publication of this document, no model or prototype has been constructed.
4. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference:
   NASA-TN-D-4102 (N67-33441), Helium Pressurant Requirements for Liquid Hydrogen Expulsion Using Submerged Gas Injection
5. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B71-10219

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

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