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NASA TECH BRIEF

Atmospheric Composition Affects Heat-and Mass-Transfer Processes

Major parts of Environmental Control Systems (ECS), such as ventilation, humidification, temperature control, and purification subsystems, are affected by atmospheric composition. Such key components as heat exchangers, condensers, and adsorption beds rely on heat- and mass-transfer processes for operation; the atmospheric gas is normally used to reject the ECS heat load; and, in some cases, a portion of the gas is processed to remove carbon dioxide and other undesired constituents. Since heat- and mass-transfer rates, together with pressure drops, depend upon the physical properties of the process gas, the performance and size of the ECS are affected by atmospheric composition.

For those ECS functions most sensitive to atmospheric composition, typical components have been test-operated in various atmospheres: helium-oxygen (He-O_2) and nitrogen-oxygen (N_2-O_2) mixtures at 5, 7, and 10 psia; pure oxygen at 5 psia; and air at 14.7 psia. The partial pressure of oxygen in the mixed-gas atmospheres was fixed at 3.5 psia. Transient heat- and mass-transfer tests were conducted for carbon dioxide adsorption on molecular sieve and for water vapor adsorption on silica gel; steady-state heat-transfer tests were run on a typical heat exchanger. Pressure drop data were obtained both for the adsorption beds and for the heat exchanger.

Sample adsorption-bed designs were generated by a computer program which used the experimental heat- and mass-transfer data. All of the molecular sieve designs were adiabatic, because the bed temperature did not increase significantly on adsorption of carbon dioxide. However, both adiabatic and isothermal designs were used for the silica-gel beds, because the high heat of adsorption and large amount of water adsorbed produced significant changes in the adiabatic bed temperatures design, thereby requiring large beds. The isothermal silica-gel beds, designed for minimum size, were between 1/3 and 1/6 the size of the adiabatic designs. An actual silica-gel bed design probably would be externally cooled during adsorption. Therefore, the size of the bed would lie between limits determined for the adiabatic and isothermal designs.

For the sample adsorption-bed designs, weight savings of up to 5% were generally obtained by using N_2-O_2 gas mixtures at higher pressure levels. In the case of the heat exchanger, some saving in total weight was obtained by using He-O_2 gas mixtures at higher pressure levels. The heat exchanger itself weighed less for N_2-O_2 gas mixtures, but this was offset by higher pressure drop, which necessitated the use of a higher-power, heavier fan motor.

Notes:

1. Information derived from this program may be applied in the design of environmental control systems used in aircraft, commercial buildings, subways, and industrial facilities.
2. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

   Reference:
   NASA-CR-891 (N67-37320), Engineering Criteria for Spacecraft Cabin Atmosphere Selection

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

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