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NASA TECH BRIEF

Calculation of Infrared Spectral Transmittances of Inhomogeneous Gases

The exhaust plume from a multiple engine rocket is a very complex gas-dynamical system. The exhaust jets from the several engines interact with the atmosphere and with each other through an intricate series of shock waves and turbulent mixing layers. To calculate the heat radiated from the exhaust plume to the rocket base, it is necessary to know the spectral transmittances of the inhomogeneous plume gases.

A general method has been developed to calculate spectral transmittances of inhomogeneous gases, such as in a rocket exhaust plume, from the properties of homogeneous gases. By this method, the calculation of spectral transmittance for a particular inhomogeneous gas path can be made by properly combining known data on gases at constant temperature, pressure, and concentration. The method is based principally on two special spectroscopic concepts: (1) the molecular band model, and (2) the Curtis–Godson approximation. The molecular band model is a mathematical representation of the effective radiant energy in portions of the spectrum where gas molecules emit and absorb energy. The band model yields an explicit, closed formula for the molecular radiation within each selected spectral region of interest, which uses as input data the averaged line strength, spacing, and half width. An average of 25 wave numbers is considered sufficient. An exponential line intensity distribution or a delta function distribution is also used in the band model. The use of a band model is critically important for practical calculations of gas radiation. Without a band model, one would have to deal individually with each of the many thousands of spectral lines that contribute to molecular radiation, a much bigger and more difficult problem, part of which is beyond solution at present. The Curtis–Godson approximation is a method of combining the parameters that appear in the band model formulas in such a way that the parameters needed for an inhomogeneous gas calculation are obtained solely from homogeneous gas data. This method has been experimentally verified for specific cases.

Note:

Inquiries concerning this method of calculation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10554

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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Category 02