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Analysis of radiative transfer in body fitted axisymmetric geometries with band models and anisotropic scattering

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ABSTRACT

The problem of radiation heat transfer in furnaces and combustors is of real practical importance. The correct estimation of the radiative heat fluxes at the walls of these furnaces requires appropriate treatment of the properties of the participating medium like absorption and scattering, along with a handle on high temperature gradients. The problem is further complicated by the spectral dependence of these properties. This is usually overcome by the use of band models. The present study aims to apply the full spectrum Spectral Line based Weighted sum of gray gases (SLW) model to body fitted axisymmetric geometries like truncated cone type enclosures which resemble to gradually expanding diffusers, rocket exhaust nozzles and typical industrial combustors that find wide engineering use. A modification of the discrete ordinates method known as MDOM has been employed to solve the radiative transfer equation. A mixture of three gases (viz. CO_2, H_2O and CO) has been considered and its spectral behaviour is modelled using SLW band model. Different particle loadings are incorporated and anisotropic scattering is modelled using transport approximation. A general purpose code SLDOM (Discrete Ordinates Method with SLW model) has been developed to handle these complexities of the problem. After a rigorous validation, a detailed analysis of the radiative heat fluxes at the curved wall is made under the influence of variable gas and particle concentrations. Finally, the methodology is applied and its behaviour is monitored in cases that involve high temperature gradient fields, such as in furnaces and combustors. Results obtained signify the importance of H_2O concentration over CO_2 and CO concentration, as the observed heat fluxes are 28% higher in the former case. The effect of concentration of gases is seen to diminish under the presence of particles. Effect of cone angle of the diffuser on the radiative heating to the wall is found to be marginal, but the peak value of the fluxes is seen to shift towards the inlet of the diffuser as the cone angle increases.

Keywords: Radiative transfer, band models, anisotropic scattering, body fitted geometries.