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RESEARCH ON RADIATION HEAT TRANSFER OF NOZZLE INNER FACE

Abstract

For radiative-cooled rocket engines, equation$q = 1.54*\epsilon$w*σ*Tw^4 was introduced to calculate total radiation heat evacuation of nozzle outer face and inner face, from which we can infer that inner face radiation heat transfer should be estimated by formula$q = 0.54*\epsilon$w*σ*Tw^4. It is reasonable to conclude that the aforementioned approximation equations imply two assumptions: first, the radiation heat exchange between nozzle segments is ignored; second, the radiation exchange factor between each nozzle inner face segment and the environment is a constant equals 0.54. The necessary and sufficient condition of above-mentioned assumptions could be expressed respectively by following formulas: (1) ΣB{ij}<<1 (2) ΣB{iE}-0.54<<1 Where B{ij} is the fraction of energy that leaves node i and is absorbed by node j by all possible reflection paths. Subscript i, j=1, 2. . . N refers to nozzle segments, E refers to the environment. To our experience, the assumptions seem to be questionable in certain cases. And there appears to be a need for a reasonable accurate, yet simple method for estimating radiation heat transfer in rocket nozzles. Actually, the radiation heat transfer of inner face is related to nozzle contour, area ratio, length, and wall emissivity. For the purpose of analyzing effects of above parameters to heat transfer, Monte-Carlo ray tracing method using SindaFluint software was introduced to calculate radiation exchange factors of a group of nozzles. The results show that: (1)B{iE} decreases with the increasing of distance to nozzle exit; (2) for nozzles having uniform area ratio, B{iE} increases with the decreasing of the length of nozzle, where i corresponding to the same area ratio location for different nozzle; (3)B{iE} increases with the decreasing of the nozzle curvature radius, it implies that reducing downstream curvature radius is better to heat transfer of throat, however has no notable effect to the whole nozzle; (4) though larger area ratio is better to heat evacuation, the effect of enhancing heat transfer is not evident when face nodes of network are close to nozzle exit; (5) radiation exchange factors of nodes near nozzle exit are merely close to 0.54. From the result, a modifying radiation heat transfer calculation method can be put forward. With the method, instead of the uniform coefficient 0.54 in formula$q = 0.54*\epsilon$w*σ*Tw^4 , different coefficients which were obtained from polynomial curve fitted with data of radiation exchange factors along nozzle axial direction, will be used for heat transfer calculation. It will improve on the calculation accuracy of thermal network.