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THE METHOD OF FAST AEROHEATING PREDICTION FOR AEROSPACE VEHICLES BASED ON REDUCED ORDER MODEL

Abstract

An accurate prediction of aeroheating environment is the prerequisite for Thermal Protection System design. Due to the complexity of aircraft shapes, flow structures such as shock/shock interaction and separation/reattachment exist around the surface, leading to local aeroheating augmentation. Conventional engineering method cannot predict such heat flux while normal CFD simulations are expensive in time. To meet the requirement in preliminary design, a method based on Reduce Order Model(ROM) is proposed to construct the aeroheating database and to predict heat flux on whole surface at given flight parameters. The proposed ROM method utilizes Proper Orthogonal Decomposition (POD) and Radius Basis Function (RBF) to correlate unknown heat flux distribution with CFD results in store. Taking a simplified space shuttle configuration as an example, heat flux distributions at certain characteristic flight parameters are calculated by a validated in-house CFD code. Heat flux under other unknown flight parameters are then predicted by the proposed method. The results show that the method in this essay is, compared with conventional CFD, much less time-consuming while not loosing significant accuracy. Furthermore, the impact of samples' envelop on prediction accuracy is discussed. The predicted heat flux distribution can resolve interference region heat augmentation and make up for the disadvantage of engineering method and pure CFD simulation. Under the condition of well-chosen CFD database, the heat flux prediction of the surface along given trajectory can be solved in 33s on a Intel Xeon server, which is only 0.15% the time for CFD simulation.The relative error between reconstructed heat flux and CFD result is less than 12%. It can be concluded that the proposed method can be an affordable tool in the preliminary design stage for thermal protection system of space aircraft.