Computational Analysis of Curved-Surface Erosion From Particle-Laden Compressible-Flow Jets

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ABSTRACT

A method for particle tracking and particle–shock interaction in compressible-flow computations was presented in [1]. The components of the method include the Variable Subgrid Scale (V-SGS) formulation of compressible flows in conservation variables [2] and $YZ\beta$ shock-capturing [3]. Particles are tracked individually, assuming one-way dependence between the particle dynamics and the flow. The method was used in simulations involving dust, sand and ash particles. Here we present a compressible-flow particle-cloud tracking method based on a turbulence closure model, which we use in conjunction with the V-SGS formulation and $YZ\beta$ shock-capturing. The erosion patterns are then computed based on the particle-cloud tracking. The method will be valuable in predicting sand damage in gas turbines, where the particles impact the turbomachinery blades. After the impact, the particles can bounce off or stick and/or erode the blade surfaces. The erosion increases the surface roughness and the amount of particles dispersed in the flow, possibly clogging the holes used for internal cooling, and certainly changing the heat removal efficiency. Detailed analysis of the particle–wall interaction is essential in improving the internal-cooling efficiency, increasing blade life and reducing maintenance cost. In the test computations we present, we account for particle-laden flow impingement on curved surfaces. This is a significant progress over standard studies, which only consider impingement on flat surfaces, without taking into account the effect of the surface curvature on the flow field or particle dynamics. Our preliminary test computations show that the erosion regions are influenced by the presence of unsteady secondary flow structures. Several peaks of erosion rate are present in both the main or orthogonal directions of the jet, and the patterns are not symmetric because of the surface-curvature effects.

REFERENCES

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