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发动机整流支板大尺寸过冷水滴撞击特性

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Supercooled Large Droplet Impact Behaviors on an Aero-engine Strut

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摘要 目前航空发动机防冰系统通用设计方案是以过冷小水滴的撞击特性为依据,但最新的研究结果显示大尺寸过冷水滴(SLD)环境下的结冰会对飞行器带来更加恶劣的影响。基于此,对大尺寸过冷水滴环境下发动机进口支板的水滴撞击特性进行了研究。首先对水滴运动控制方程进行了修正,以模拟水滴的变形及破碎的影响;然后对水滴在壁面处飞溅、反弹现象进行了机理研究,给出了大尺寸过冷水滴撞击特性计算的数学模型;最后对尾部可调的发动机进口支板在调节角度分别为0°与30°、水滴当量直径(MVD)为120 μm时的水滴撞击特性进行了数值模拟。研究结果显示:调节角度为0°时,水滴在驻点附近区域处于不稳定状态,破碎成MVD较小的水滴,支板驻点处由于水滴飞溅造成水滴收集系数下降了11.8%,同时由于水滴在局部地方的反弹使得撞击极限下降了35.7%;调节角度为30°时,水滴在运动中没有破碎,但是在支板可调部分表面水滴全部反弹。

关键词: 航空发动机 防冰系统 发动机整流支板 大尺寸过冷水滴 撞击特性 数值模拟

Abstract: Presently design of anti-icing systems for aircraft engines is generally made for small droplet icing conditions. However, recent research shows that icing accretion due to supercooled large droplet (SLD) may result in extremely severe aircraft or engine performance degradation. With reference to the impact behavior of SLD on an aero-engine strut surface, a numerical method is presented in this paper to model some important phenomena and effects for the SLD, including deforming, breakup, splashing, rebounding, etc. Some semi-empirical computational models drawn from the literature are incorporated into the Eulerian droplet field equations. Comparisons are then made between the impingement characteristics on struts surface in two different regulated angles with an icing cloud median volumetric dimeter (MVD) of 120 μm. Results show that, when the regulated angle is 0°, some smaller droplets are formed because of the breakup effect. Also, due to the splashing and rebounding influence the droplet collection efficiency and impingement limit decrease by 11.8% and 35.7%, respectively. In contrast, no breakup phenomenon is observed when the regulated angle is 30°, and all the impacting mass rebounds away from the regulated surface.

Keywords: aircraft engine anti-icing system aero-engine strut supercooled large droplet impact behavior numerical simulation

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