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Effect of nozzle rotation angles and sizes on thermal characteristic of swirl anti-icing †

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Abstract

The Federal Aviation Administration requires all aircraft manufacturers to adhere to maximum noise level standards. Thus, a bias acoustic liner is introduced, to intensify the noise equipment system, as well as prevent ice accumulation on the nacelle D-chamber. The hotspot phenomenon, by the Piccolo tube anti-icing system, could damage the bias acoustic liner. Therefore, a swirl anti-icing system is further investigated, to reduce the hotspot effect on the bias acoustic liner. The present work investigates the effect of nozzle rotation angles at various mass-flow-rates of hot-air supplied on the nacelle lip-skin temperature distribution, in order to enhance the swirl anti-icing system's performance. The effect of the nozzle ratio area on the swirl anti-icing system's performance to be discussed in the present work. The simulation results show that the hotspot temperature decreases by 26 % and the cold spot temperature increases by 18 %, as the nozzle to be rotated from 0° to 13° towards the inner skin. However, the nozzle ratio area shows a negative effect on the swirl anti-icing performance, where the hotspot temperature increases by 6.7 % and the cold spot temperature decreases by 30.2 % with the ratio nozzle area increasing from 0.1083 to 0.8354. According to swirl anti-icing empirical values, the average Nusselt number is directly proportional to the average Reynolds number. In conclusion, the temperature distribution on the nacelle lip-skin and the swirl anti-icing system's performance improves as the angle of nozzle direction increases, rotating towards the inner skin. Swirl anti-icing does not generate hotspot on the inner skin, thus making it suitable for use in a bias acoustic liner system.

Keywords: Cold-spot; Hotspot; Nusselt number; Nacelle lip-skin; Reynolds number; Swirl anti-icing