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Title

Study on the Influence of Vortex Generator on Aerodynamic and Stealth Characteristics of Serpentine Inlet

Authors

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Abstract

The serpentine inlet has good electromagnetic stealth characteristics, and its compact and curved pipe wall also makes it easy to install and integrate the inlet with the aircraft fuselage. Under the current development trend of highly integrated propulsion system and aircraft, the serpentine inlet has been widely used in military aircraft and unmanned aerial vehicles. The serpentine inlet can block the view of complex components such as the fan inside the engine through the curved wall, thus reducing and attenuating the radar echo signal. However, due to the large bending of the serpentine inlet pipe, the flow field characteristics are adversely affected by the combined effects of the inverse pressure gradient along the way, centrifugal force and transverse pressure difference. In order to improve the aerodynamic performance of serpentine inlet, vortex generator(VG) is used in this paper. At the same time, the VG will change the three-dimensional shape of the inlet, and affect the electromagnetic scattering characteristics and radar scattering cross section(RCS) of inlet, thus it is necessary to study the influence of VG on the electromagnetic scattering characteristics of the serpentine inlet, but there is no relevant research on this aspect at present, and the aerodynamic performance and electromagnetic stealth characteristics of the inlet often conflict. Therefore, this paper designed several groups of VGs with different parameters to explore their effects on the aerodynamic performance and electromagnetic stealth characteristics of the serpentine inlet. On one hand, a semi-circular inlet with double S-bends is designed by using the control curvature parameterization method. The effects of four installation positions, four numbers and six heights of straight plate VGs on the aerodynamic performance and electromagnetic scattering performance of serpentine inlet were investigated by numerical simulation. The results show that the VG can significantly improve the aerodynamic performance of the inlet. The use of VG can reduce the circumferential total pressure distortion by 57.8% and the swirl distortion by 53.3%. And the total pressure recovery is reduced by 1.4% at most, which is within the acceptable range. The VG has a strong position sensitivity to the flow control effect of the serpentine inlet, and different installation positions have different optimal heights and quantities.

On the other hand, in this paper, the iterative physical optics (IPO)method written by C++ program is used to analyze the influence of VG with different parameters on the electromagnetic scattering characteristics of serpentine inlet. It is found that VG will affect the peak and mean value of the RCS of inlet, making the RCS curve oscillation of the inlet more intense. The propagation of electromagnetic wave in the inlet cavity will be blocked by the VG, and the diffraction phenomenon will occur on its surface. At the same time, due to multiple reflections between the VG and the inlet outlet wall, there will be strong induced current in this area. Through the analysis of the induced current diagram, it can be seen that the edges of the VG enhance the electromagnetic edge diffraction phenomenon, which increases the mean RCS of the inlet. The more the number of VGs, the greater the RCS of the inlet. When the number of VGs is 19, the RCS of the two electromagnetic wave polarization modes increases by 136% and 166.9% compared with the inlet without VGs. In addition, as the height of the VG increases, the RCS of the inlet increases.