Paper ID: 61930
student

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Environmental Effects and Spacecraft Protection (6)

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ACOUSTIC RADIATION SOURCES ANALYSIS DURING LAUNCH VEHICLE LIFT-OFF WITH DIFFERENT GAS DUCTS

Abstract

The launch vehicle lift-off is accompanied by the occurrence of quite significant gas-dynamic, thermal and vibration-acoustic loads. They can lead to the destruction of both the launch vehicle and payload, and the ground complex. Gas-dynamic and thermal loads, in general, affect only the launch pad, and vibro-acoustic loads also affect the entire environment nearby. There are various ways to reduce the acoustic impact - using soundproofing elements, protective screens, emissions of large amounts of water on the launch facilities. A decrease in the effect of the jet on the launch structures elements is also achieved by the engine gas jet flow directed into a special gas duct. The purpose of this work is analysis of the acoustic radiation sources in the gas duct at the launch of a rocket with a single-nozzle propulsion system with different gas reflectors; assessment of the impact of the flue depth on the sound pressure level in the near and far acoustic field. The launch vehicle gas-dynamic lift-off simulation from the launch pad, where the gas jet flows are discharged with gas duct, has been performed. The distance between the nozzle exit and the gas duct entrance is 9400mm. The Mach number at the nozzle exit is 3.95. The nozzle pressure ratio is 0.48. During simulation, the flue depth takes on the values is 5500mm, 6500mm, 7500mm. The total acoustic power analysis is carried out in the area of the supposed fairing at a point located at a distance of 48000mm from the nozzle exit. This problem was solved using a numerical method in two stages. At the first stage, the gas dynamic characteristics of the flow were analyzed using the Reynolds-averaged Navier-Stokes equations using the k-w SST turbulence model. The acoustic radiation sources were analyzed too. A broadband noise model was used for this. At the second stage, the sound pressure level in the frequency ranges was determined. The Ffowcs Williams-Hawkings method and the DDES turbulence model was used. On the basis of the calculation results, the Mach number, pressure, temperature and the acoustic power level contours inside the gas duct were constructed. It was found that with an increase in the gas duct depth, the free gas jet flow acoustic power remains virtually unchanged, but the noise radiation acoustic power level in the near field decreases. This also leads to the overall sound pressure level decreasing in the area of the supposed fairing.