Abstract

A launch vehicle experiences intense acoustic loading in the initial phase of its lift-off due to the noise generated by the rocket exhaust. This affects the launch vehicle structure in addition to sensitive payloads and may result in their failure. The launch vehicle structure has to be specially stiffened to withstand such loading which adversely affects its payload capabilities. Therefore, the mitigation of the lift-off acoustic environment of the launch vehicle is of utmost importance. At lift-off, the components of launch environment such as the launch platform and jet blast deflector contribute to the intense acoustic loads experienced by the launch vehicle by either reflecting the noise generated by the rocket jet exhaust or by creating additional sources of noise. Though the effect of jet blast deflector shape on the acoustic loading has been extensively investigated, contributions from other launch structures such as the launch platform are often ignored. The present work attempts to characterize the acoustic behaviour of the launch platform by simulating a scaled down launch vehicle environment at lift-off, inside an anechoic chamber. The lift-off scenario was simulated by allowing jets from single and twin jet launch vehicle models to impinge on flat plates with and without cut-outs, at varying lift-off distances. The results from the acoustic measurements carried out in the near and far-field of the launch vehicle models show that the presence of the cut-outs have significant effect on the near-field acoustics of the launch vehicle at low lift-off distances(L/De). The acoustic field in the vicinity of the launch vehicle is found to be considerably lower than that obtained when jets impinged on solid flat plates without cut-outs. The influence of the cut-outs, diminishes at higher L/De, when a large fraction of the jet, in addition to flowing through the cut-outs, impinges on the launch platform. The study also explores a new concept of including perforations in the launch platform as a means to attenuate the its contribution to the acoustic levels experienced by the launch vehicle. The inclusion of perforations in the launch platform, decreased the surface area of the launch platform available for jet impingement at higher L/De, thereby reducing the acoustic levels experienced by the launch vehicle at these lift-off distances. The perforated launch platform is found to be effective even with the presence of jet blast deflector, all the way up to 16 nozzle diameters after lift-off. Flow visualizations using schlieren technique indicate that the effectiveness of the perforations stem from the fact that they reduce the strength of the flow features such as wall jets and fountain flow - that are characteristic of jet impingement. The thesis brings out the significant contribution to the lift-off noise from a typical launch platform and the role of flow features like the wall jets and the fountain flow towards noise generation. It is shown that an attenuation of about 4-5 dB can be achieved at L/De>8 by perforating the platform. An optimal design of the launch platform incorporating the perforations can considerably reduce the acoustic loading of the launch vehicle thereby increasing its payload capabilities and ensuring its safety.