Abstract

An explosive event in an industrial gas transmission pipe stresses the pipe and can result in pipe rupture and separation at weak points. A shock wave results propagating from the high pressure section of the pipe, through the gap and to the low pressure section. The present study simulates numerically and experimentally the resulting flow field at the position of pipe separation and propagation conditions in both pipe sections. The effects of gap width, gap geometry and shock Mach number variation are investigated. Shock Mach numbers of 1.34, 1.45,1.60 and 2.2, gap widths of 40mm to 310mm were used. All variations of boundary conditions were found to have an effect on the propagation conditions as well as the development of the flow features within the gap. The variation of the gap geometry was done for a pipe gap and a flanged gap experimentally. Extended geometries were simulated numerically. For the pipe gap, the incident shock wave accelerated the gas in the upstream pipe to high subsonic speeds and continued in the downstream pipe at a much reduced strength. A strong expansion propagated into the flow in the upstream pipe causing a significant pressure drop from the initial post-shock pressure. Expansion waves at the outflow resulted in supersonic speeds as the flow entered the gap for Mach 1.45 and 1.6. A notable feature was the formation of a standing shock at the inlet to the downstream pipe. In addition to the standing shock, shock cells of alternating shocks and expansions developed within the gap essentially controlling the propagation conditions in the downstream pipe. For the lower Mach number of 1.3, no sharp discontinuities were noticed. The effect of the gap width was found on the nature of the shock cells within the gap. The propagation conditions in the downstream pipe showed that the pressure is initially unsteady but becomes more uniform, controlled by the developed wave system in the gap. For the flanged gap case, the flow within the gap is confined for much longer and hence produced much more intense and complex flow feature interactions and an earlier transition of the flow to turbulence. Numerical investigations for a burst pipe gap, for a gap with a different diameter downstream pipe and a gap with a 90-degree bend downstream pipe produced peculiar flow features.