

Abstract

Flow around flat plates that were uniformly accelerated from rest with acceleration of 13g is analysed with overset mesh from Star CCM+ commercial CFD software. The particular interest is more on the vortices shed from the plate edges. Three 8mm thick plates of the same cross-sectional areas (108mm length equilateral triangular, 71mm length square and 80mm diameter circular) were simulated. The validation of the numerical method was achieved by using laser vapor sheet method to visualize the flow profiles of accelerating circular plate and comparing the CFD and experimental results. The CFD and experimental results were consistent with each other.

It was found that when a plate accelerated in air, it displaced air particles out of its way. The shear layers of air separated from the front edges of the plate and rolled around a vortex core forming a primary vortex ring in the plate wake. The size of the primary vortex increased with Reynolds number (Re) that was increasing with time. This was because as Re increased, more fluid particles were displaced from the front face of the plate at a time. More displacement of the fluid particles led to shear layers separating from the plate edges with stronger momentum resulting in larger vortex ring. The shape of the primary vortex depended on the shape of the accelerating plate. For the circular plate, all the points on the front edge being equidistant from the plate centroid, fluid particles were evenly displaced from that separation edge. The result was an axis-symmetric ring of primary vortex around a circular vortex core. The asymmetric plates (triangular and square) did not evenly displace air particles from their edges of separation. The result was an asymmetric vortex ring. More air particles separated from the plate at separation points closest to the plate centroid and led to the largest vortical structure there. That is; the primary vortex ring was largest at the midpoints of the plate edges because they were the closest points of separation from the plate centroid. The size of the primary vortex continuously reduced from the mid-points of the plate edges to the corners. The corners had the smallest primary vortical structure due to being furthest points of separation from the plate centroid. The parts of the vortex ring from the two edges of the plate interacted at the corner connecting those edges.