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Portfolio Paper

On the Collision of Compressible Vortex Ring with Wall

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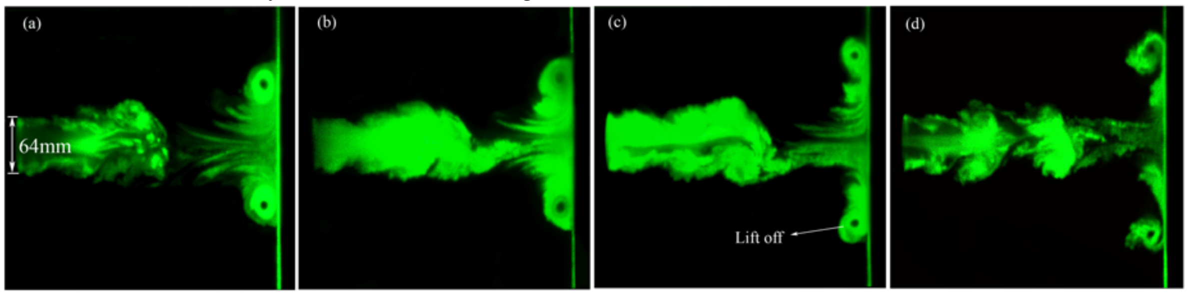

Fig. 1. Vortex ring Wall interaction for M = 1.31 (a) 3367 μs (b) 3517 μs (c) 3717 μs (d) 3917 μs.

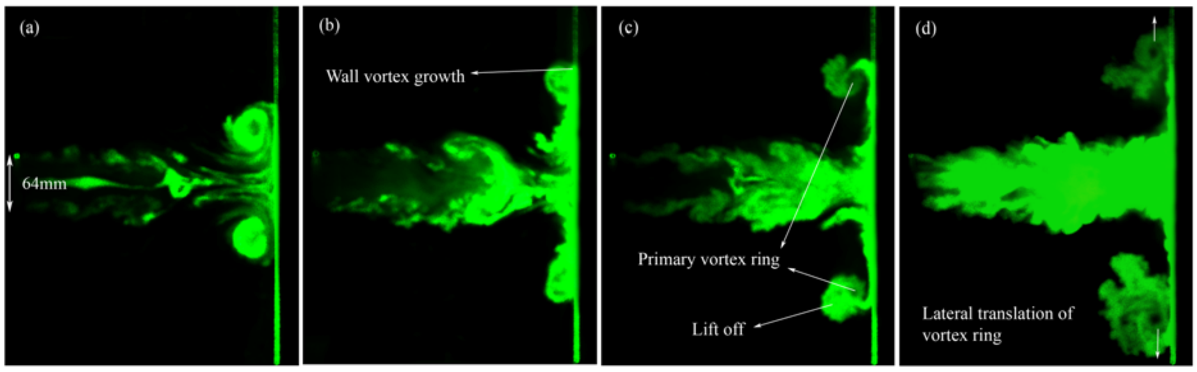

Fig. 2. Vortex ring Wall interaction for M = 1.55 (a) 1983 μs (b) 2433 μs (c) 2676 μs (d) 3426 μs.

Figure 1 and 2 show the cross sectional view of the compressible vortex ring generated at the open end of the shock tube[1] impinging on a plane wall for two shock Mach numbers, M = 1.31 and 1.55. The driver and driven section length of the shock tube are 115 mm and 1200 mm respectively. A square plate is kept at 300 mm from the shock tube exit to study the vortex ring wall interaction. Experiments are performed with helium as a driver section gas. Flow field of the vortex ring is illuminated using paraffin oil smoke and laser sheet. A CCD camera synchronized with double pulsed Nd-YAG laser using an external delay unit to capture the flow field at different times.

Reynolds numbers (Re) of the ring after pinching off are 4.75×10^5 and 9.15×10^5 for M = 1.31 and 1.55 respectively. Vortex ring core is laminar for M = 1.31. Stretching and deformation are small during impingement. However for M = 1.55, vortex ring core is turbulent. Hence stretching and deformation are severe due to large Re (Fig. 1(b) and 2(b)). Compressibility plays major role during shocklets[2, 3] formation in the flow field near the wall which are captured using optical methods (schlieren and interferometry). As the vortex ring impinges, a secondary vortex with opposite vorticity is formed near the wall due to boundary layer separation. This secondary vortex lifts off with the primary vortex ring after attaining maximum circulation. The lifting off process is also strong for high Re (M = 1.55) compared to Low Re (M = 1.31). For incompressible vortex, the vortex pair (primary and secondary) moves towards the axis and becomes turbulent structure[4, 5]. Whereas here, the primary ring moves along the wall after the secondary vortex diffuses near the wall due to its large circulation.

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