The analytical model for vortex ring pinch-off process based on the energy extremum principle YANG XIANG, HONG LIU, SUYANG QIN, FUXIN WANG, Shanghai Jiao Tong Univ — The discovery of vortex ring pinch-off is greatly helpful for us to understand the mechanism of optimal vortex formation, which further implies the optimal biological propulsion for animals. The vortex ring pinch-off implies its limiting formation and is dominated by the energy extremum principle. However, it is found that vortex ring pinch-off is a continuous process rather than a transient timescale. Therefore, we are wondering that how to identify the onset and end of pinch-off process. Based on the Kelvin-Benjamin variational principle, a dimensionless energy number is adopted to characterize the energy evolution of vortex rings. The vortex ring flow fields are obtained by DPIV with the piston-cylinder setup, and their geometric structures are identified using its Lagrangian coherent structures. The results show that the dimensionless energy numbers with the steady translating vortex rings share a critical value. It is then demonstrated that the dimensionless energy number dominates the onset and the end of pinch-off process. Besides, the onset and end of pinch-off can also be identified using LCSs. Additionally, based on the dimensionless energy number or LCSs, the corresponding vortex ring formation times(L/D) for the onset or the end of pinch-off are consistent.

Yang Xiang
Shanghai Jiao Tong Univ

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