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A Model for the Formation of ‘Optimal’ Vortex Rings with Taking into Account Viscosity

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The evolution of a viscous vortex ring from thin to thick-cored form is considered using the improved asymptotic, which is obtained after impressing a spatially uniform drift on the first-order solution of the Navier–Stokes equations. The obtained class of rings can be considered as the viscous analogy to the Norbury vortices and classified in terms of the ratio of their initial outer radius to the core radius. The model agrees with the reported theoretical and experimental results referring to the post-formation and the formation stages. By using the matching procedure suggested earlier and the obtained properties of the viscous vortex ring, it is found that when the length-to-diameter aspect ratio L/D reaches the limiting value 4.0 (‘formation number’), the appropriate values of the normalized energy and circulation become around 0.3 and 2.0, respectively. An approach that enables to predict the ‘formation number’ is proposed.

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