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The spread of transient circular liquid jet and hydraulic jump formation

Abdelkader Baayoun[1], Yunpeng Wang[2] and Roger Khayat[1*]
[1]Department of Mechanical and Materials Engineering, University of Western Ontario, London, Ontario, Canada N6A 5B9
[2]Guangdong Provincial Key Laboratory of Turbulence Research and Applications, Center for Complex Flows and Soft Matter Research, Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, Shenzhen 518055, People's Republic of China

*rkhayat@uwo.ca

ABSTRACT

Circular hydraulic jump is normally formed due to circular jet impingement on a horizontal disk. Prediction of the jump location in particular is important due to its relevance to numerous practical applications such as jet cooling, jet quenching, and surface cleaning. Previously developed theories of the laminar axisymmetric flow have only focused on the steady-state hydraulic jump. However, upon varying certain physical parameters with time, the developed jump begins to exhibit a transient change. We focus in this work on the situation where transition from one steady-state to another occurs, and we present a fully predictive theory of the transient behaviour of the developed circular hydraulic jump. The theory is validated against numerical simulation for the case of a linearly increasing jet flow rate and against experiment on the sudden drop of gravity from its normal level to a low level. Both comparisons yield good agreement. While the supercritical flow exhibits a transient change, and sometimes a long-term one, when the jet flow rate linearly increases from one steady-state to another, it remains steady when gravity level is lowered. Consequently, for the first case, the jump radius evolution is strongly affected by inertial effects, while for the second case; it shows a same transient period as the one needed by gravity to reach its final level.

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