Accumulation of a light non-aqueous phase liquid on a flat barrier baffling a descending groundwater flow

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Abstract

The pioneering solution of Zhukovskii for a steady two-dimensional flow of an ideal heavy fluid with a nonlinear free boundary condition is extended to a Darcian flow of groundwater encumbered by an impermeable barrier. The stoss or/and lee sides of the barrier are covered by a macrovolume of a liquid contaminant. Explicit parametric equations of the sharp interface are obtained by inversion of the hodograph domain. Zhukovskiis gas-finger shape is shown to be a particular case of our new class of free surfaces. For a cap of a light liquid, partially covering the roof, from the given crosssectional area of the cap, the affixes of the conformal mapping are found as a solution of a system of two nonlinear equations. The horizontal width and vertical height of the cap are determined. If the dimensionless incident velocity is higher than the density contrast, then the interface (cap boundary) cusps at its apex. For a relatively small velocity, the interface spreads to the vertices of the barrier, the apex zone remaining blunt shaped. We depict all the relevant domains and plot the flow nets using computer algebra routines. © 2012 The Royal Society.

Keywords

Conformal mappings, Hodograph, Holomorphic functions, Nonlinear free boundary problem, Two-dimensional flow of heavy ideal fluid - seepage