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Viscoelastic Muds—Top-Kill in Rapidly Flowing Wells[1]

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The attempted "top-kill" of the blown out Macondo (Deepwater Horizon) oil well by pumping a dense drilling "mud", *i.e.*, a slurry of dense minerals, from above failed. This failure may be attributed to a Kelvin-Helmholtz instability in the gravity driven counterflow between the descending "mud" and the rapidly upwelling crude oil. The instability produced turbulence that dispersed the denser fluid into small packets (if miscible with the oil) or droplets (if immiscible). Estimates from turbulence theory imply that the packets or droplets are so small (sub-mm) that their settling speed in the oil is less than the upwelling speed, with the consequence that the "mud" is spat out of the well, as observed, rather than descending to fill the bottom of the well bore and providing the hdyrodstatic head required to "kill" the well. The addition of a shear-thickening or viscoelastic polymer to the "mud" may suppress the turbulence and prevent its dispersal. Laboratory experiments with viscoelastic surrogate "muds" show complete turbulence suppression at the relevant speeds, with the viscoelastic fluid descending as a coherent slug. These experiments find several new phenomena. At high flow rates there is a viscoelastic analogue of the viscous buckling instability. At low flow rates suppression of the Plateau-Rayleigh instability combined with the dependence of viscous flow rate on diameter leads to the formation of globules on a looping filament.

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