Viscous Fluid Mixing in an Annular Slot

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The problem of viscous fluid mixing is important for chemical technology and food industry. Molecular mixing – diffusion- takes too long, placing paddles of other bodies to the mixing area can lead to large mechanical torque due to drag force. We consider flows of viscous fluid with admixtures in an annular slot and liquid is moved by rotation of its boundary. Two forces mainly act on a liquid particle, namely viscous friction and inertia. Their relation defines the flow structure. We found three different regimes. If viscosity dominates, the flow is quasi-steady. In this regime, admixtures can be spread over thin layer and then gathered back, if the boundary returns to the initial position. For slightly lower viscosities, we still have laminar flow, admixtures cannot leave their layer, but the flow is irreversible. If centrifugal force dominates over viscosity, the laminar flow is unstable, and Taylor vortices appear in the slot. We constructed devices to investigate these flow. They consist of pairs of glass cylinders, glycerol and silicone oil were used as a liquid and colored liquid and aluminum powder were added to visualize the flows. We simulated the motion of admixtures numerically and obtained places where a given particle can be moved by the flow. If the flow is quasi-steady, admixtures can be returned to initial position. If the flow is faster but laminar, they stay in an initial layer. If Taylor vortices appear, they quickly spread across the slot. After some time, admixtures fill the whole slot.

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