SHEAR-INDUCED STRUCTURING AND RHEOLOGY OF TWO-LAYER IMMISCIBLE FLUIDS

S.A. Patlazhan[1], I.V. Kravchenko[2]

1 - Semenov Institute of Chemical Physics of Russian Academy of Sciences, Moscow, Russia
2 - Institute of Problems of Chemical Physics of Russian Academy of Sciences, Chernogolovka, Russia

sapat@yandex.ru

Numerical modeling of structural transformations and related rheology of two-layer immiscible viscous and power-low fluids is discussed. The attention is focused on studying the unstable mode of shear flow in terms of nonlinear development of interfacial disturbances and corresponding evolution of effective viscosity of the 2D system. Particularly, an influence of interface slip boundary condition inherent to incompatible polymer melts is analyzed.

The unstable shear flow leads to formation of the viscous fingers [1]. We found that their morphology is depended significantly on the viscosity m and thickness n ratios of the lower to upper layers (see Fig. 1). This dependence manifests itself in rising of the end drop attached to the viscous finger at $m > 1$ and $n < 1$. The interfacial tension induces capillary waves resulting in disintegration of viscous fingers to a set of small drops (Fig. 2) at certain deformation.

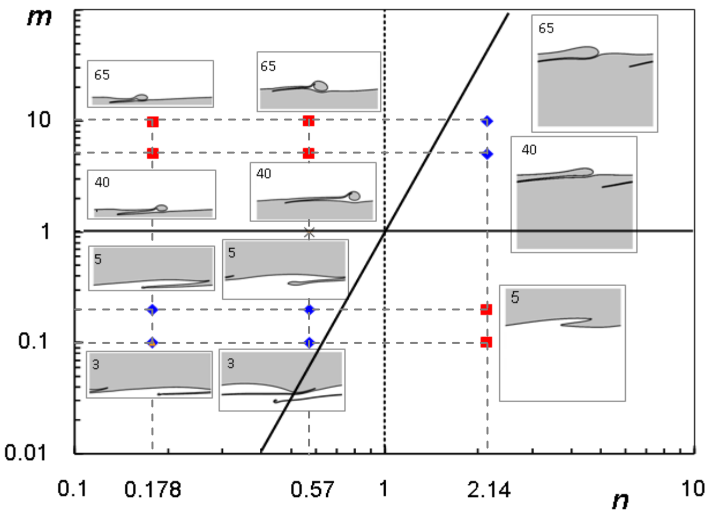
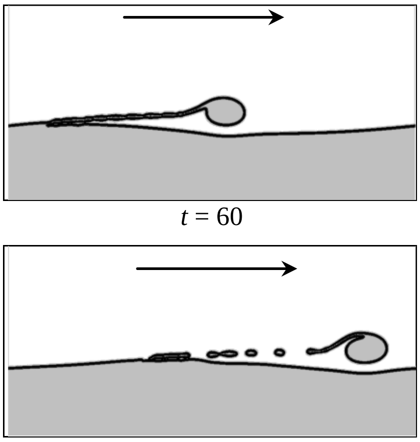


Figure 1. Diagram of dynamic states of sheared two-layer system at different viscosity and thickness ratios. Numbers on inserts correspond to the dimensionless processing time.



$t = 60$

$t = 55$

Figure 2. Development capillary instability of viscous fingers.

It is shown that increase of viscosity ratio decrease critical elongation of viscous fingers. This effect stays behind mechanism of emulsification of the stratified system.

The interfacial slip is found to increase rate of deformation of viscous fingers: the larger is the extrapolation length describing slippage intensity, the longer are viscous fingers. This should enhance interfacial adhesion of immiscible polymers due to their mechanical anchoring in the solid state. The similar effect was revealed for the power-law fluids under the stick boundary condition. This is explained by reduction of viscosity of the fingers caused by the local shear rate.

The instantaneous effective viscosity of the two-layer system at the arbitrary interface structure is estimated. The derived evolution of the effective viscosity correlates with the characteristic interface structure developing during the unstable shear flow.

[1] J. Li and Y. Renardy “Numerical study of two immiscible liquids at low Reynolds number”, SIAM Review, **42** 417 (2000).