高 分 子 学 会 九 州 支 部 講 演 会

Viscous Heating Effects in Slot-die Coating

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主催：高分子学会九州支部

共催：九州大学先導物質化学研究所九州大学分子システム科学センター、
高分子機能創造リサーチコア

日時：2014 年 10 月 24 日（金）16:00-17:30

場所：九州大学伊都キャンパス 物質系 5 番教室（ウエスト 4 号館 315 号室）

参加費：無料

Brian Higgins 先生は UCDavis 名誉教授で、流体力学、塗布,薄膜の安定性に関する多くの業績を上げられています。現在、東京理科大、Hanoi University of Mining and Geology 客員教授であり、東京大学、大阪大学でも講義を行っておられます。今回、九州大学訪問の機会に講演会を企画しました。多数ご出席くださいますようご案内申し上げます。

Abstract

Slot-die coating is a premetered coating method that has found wide application in the thin film coating industry. In slot-die coating, the volumetric flow rate through the die is adjusted with a metering pump, and thus directly defines the wet film thickness for a given coating width and line speed. The minimal achievable wet film thickness is limited by the stability of the liquid bridge between the die lip and the moving substrate. The details of this stability limit are now well established, both theoretically and experimentally, see for example, Higgins and Scriven (1980) and Wengeler(2014).

When slot-die coating is used to coat high viscosity fluids (e.g., polymer melts and lithium-ion cathodes), rheological properties of the coating fluid put additional demands on coating stability. In this presentation we will examine the roll of viscous heating effects in the slot die when the coating fluid is subject to high shear rates. Remarkably this effect has never been addressed in the literature. We will examine the case when the fluid viscosity has an Arrhenius dependence on temperature, and its shear rate dependence is described by a Carreau-type model. Through numerical simulation we will show how viscous heat effects can change the stability limits of a slot coater. In particular, we will discuss viscous heating effects in three representative slot die geometries: standard, overbite and underbite. The effects of viscous heating will be accounted for through an appropriately defined Brinkman Number (which measures the relative importance of viscous heating to conductive heat transfer). We also show that for certain coating conditions, the stability of the liquid bridge may be subject to hysteresis effects, related to an imbalance of heat generated in the coating bead due to viscous dissipation and the ability for that heat to be conducted away through the die/web surfaces.

Note: the presentation will focus on the physics of the problem not the underlying mathematics so that non-experts can fully appreciate the consequences of viscous heating and how these effects can be mitigated.

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