

107

Magnetic fluid flow from a slot with moving boundary

Author: Yuriy Raikher¹

Co-author: Denis Goldobin¹

¹ *Institute of Continuous Media Mechanics of the Ural Branch of Russian Academy of Sciences*

We study the effect of a constant magnetic field on the entrainment of magnetic fluid (MF) by a moving boundary of a plane slot. The field is imposed by an external magnet. Under field-gradient forces, an MF bridge forms inside the slot. When one of the boundaries is set into motion, wetting causes it to drag away a thin MF film.

To determine the profile of the bridge edge and the amount of MF dragged out by viscous forces (counteracted by magnetic forces), the fluid mechanics equations are first solved separately in two regions: the steady meniscus at the bridge edge and the withdrawn MF film. These solutions are then matched to obtain a complete description of the flow. Notably, the problem in the remote region is essentially singular and therefore requires sophisticated mathematical treatment.

In the absence of a magnetic field, the fluid mechanics of the system can be described using the Landau–Levich (LL) approximation with suitable modifications. In the presence of a magnetic field, however, one must additionally account for ponderomotive forces within the MF bulk and for the additional pressure jump at the free surface. These contributions substantially modify both the film flow, reducing the amount of withdrawn fluid, and the capillary pressure beneath the meniscus, effectively preventing rupture of the fluid bridge at any slot thickness. Moreover, unlike ordinary fluids, the MF withdrawal is shown to saturate at large slot thicknesses.

The obtained solution extends the classical Landau–Levich approach to fluids with high magnetic susceptibility, where an external magnetic field acts as an additional control parameter. Since the Landau–Levich solution forms the theoretical basis of slot-die coating technology, the present extension may be of practical interest. In addition, the analyzed MF dynamics serves as a prototype for the operation of acoustic contacts in ultrasonic non-destructive testing when magnetic fluids are used as immersion media [1,2].

The work was carried out within project 075-15-2024-535 of 24.04.2024 funded by RMES.

References

- [1] D. Y. Chung, *The use of magnetic fluids in ultrasonic non-destructive test applications*. In: Abstracts of the IVth International Conference on Magnetic Fluids, Tokyo & Sendai, 1986, pp. 84–85.
- [2] V. Korovin and Yu. Raikher, *Application of magnetic fluids in ultrasonic non-destructive testing*. Elsevier Studies in Applied Electromagnetics in Materials, Vol. 1: *Electromagnetic Forces and Applications*, Elsevier, Amsterdam, 1992, pp. 107–110.

Type:

Oral