VTT Technical Research Centre of Finland

Pipe rheology of wet coating foams

Jäsberg, Ari; Viitala, Janika; Tanaka, Atsushi; Prakash, Barani; Koponen, Antti I.

Published: 01/06/2023

BUENOS AIRES 2023
JUNE 4 - 8

WCCE11 - 11th WORLD CONGRESS OF CHEMICAL ENGINEERING
IACCHE - XXX INTERAMERICAN CONGRESS OF CHEMICAL ENGINEERING
CAIQ2023 - XI ARGENTINIAN CONGRESS OF CHEMICAL ENGINEERING
CIBIQ2023 - II IBEROAMERICAN CONGRESS OF CHEMICAL ENGINEERING
Buenos Aires - Argentina - June 4-8, 2023
"The global chemical engineering working for a better future world"

Pipe rheology of wet coating foams

Ari Jäsberg, Janika Viitala, Atsushi Tanaka, Baranivignesh Prakash, and Antti Koponen

VTT Technical Research Center of Finland Ltd, P.O. Box 1603, 40401 Jyväskylä, Finland.

email: Antti.Koponen@vtt.fi

Objectives

In paper and board making, additives have traditionally been added to the pulp suspension before forming. More recently, spray coating of the additives has been developed, which gives such advantages as increased mechanical retention and better wet strength without impairing the sheet uniformity. Spray coating, however, creates mist, has difficulties in dealing with highly viscous fluids and suffers from clogging of the spray nozzles. Foam coating, which is widely used in the textile industry [1], gives the advantages of spray coating without its disadvantages. This technology is currently being developed also for the pulp and paper industry. To engineer processes utilizing foam coating, the complex flow behavior [2,3] of the coating foams must be quantified.

Materials and methods

Polyvinyl alcohol (which is a widely used strength additive) and an experimental additive were used as surfactants. Their concentration was widely varied to study the effect of the viscosity and surface tension of the base solution on the foam properties. The air content of foams, generated with a commercial foam generator, was varied between 0.7 and 0.9. The rheological properties of foams were measured with three horizontal pipes (D = 8, 12 and 19 mm). Here, the volumetric flow rate, slip velocity, pressure gradient and bubble size distribution were measured. In the viscosity analysis, the real shear rate at the pipe wall was calculated by applying the Weissenberg-Rabinowitsch correction. Notice that we used a pipe rheometer [4,5,6] instead of a rotational rheometer to minimize the disturbance due to the dying of foam and to measure the foam slip behaviour [3] in process-like conditions.

Main conclusions

Generally, the foam viscosity/slip velocity is a function of air density, air content, solution density, solution viscosity, solution surface tension, bubble size, and shear rate/wall shear stress. These quantities were written in a dimensionless form by using dimensional analysis. Then, by using regression analysis, accurate formulas for the foam viscosity and the slip flow were found that were similar to the theoretically derived formulas presented in Ref. [3].

References

1. Kenttä, E., Kumar, V., Andersson, P., Forsström, U. (2022). A Novel foam coating approach to produce abrasive structures on textiles, *Autex Research Journal* 22(3), 335 – 342.
2. Weaire D. (2008). The rheology of foam, *Current Opinion in Colloid & Interface Science*, 13(3), 171– 176.
3. Denkov, N., Subramanian, V., Gurovich, D., Lips, A. (2005). Wall slip and viscous dissipation in sheared foams: Effect of surface mobility, *Colloids and Surfaces A: Physicochemical Engineering Aspects* 263, 129–145.
4. Kroezen, A. Wassink J. and Schipper, C. (1988). The flow properties of foam, *JSDC*, 104, 393-400.
5. Gardiner,B., Dlugogorski, B., Jameson, J. (1999). Prediction of pressure losses in pipe flow of aqueous foams, *Industrial & Engineering Chemistry Research*, 38, 1099-1106.
6. Larmignat, S., Vanderpool, D., Lai, H., Pilon, L. (2008). Rheology of colloidal gas aphrons (microfoams), Colloids and Surfaces A: Physicochem. Eng. Aspects, 322, 199–210.