SYSTEMATIC STUDY OF COATING SYSTEMS WITH TWO ROTATING ROLLS

F. BALZAROTTI and M. ROSEN

Grupo de Medios Porosos, Facultad de Ingeniería, Universidad de Buenos Aires, Argentina.
mrosen@fi.uba.ar

***Abstract*−The coating method called "Roll Coating" is one of the most widely used in industry and consists in the application of fluids through rotating rolls. In this work we examine the system of two cylinders in rotation. The aim of this presentation is to characterize this system of two cylinders for different ratio of velocities (s) and gap configurations, in order to build a phase diagram that identifies the resulting thickness for each set of operation parameter values. Resulting thicknesses were contrasted with classical models to test its validity limits. The classical models, which are based on the Theory of Lubrication, and their corresponding simplifying hypotheses, let us demonstrate the significant dependency of the outlet thicknesses with regard to the gap and the velocity ratio and the modified Capillary number β. When the amount of fluid dragged increases, an irregular V-shaped cross-site wave appears, repeated quasiperiodically down-web (Cascade effect), indicating the region of parameters in which the phenomenon is present.**

***Keywords*−−Roll coating, Seashore Phenomenon.**

I. INTRODUCTION

The coating of surfaces with a liquid film is a process found in many applications. It is extensively used in the paint, paper, photography, magnetic tape and packaging industry to cover a large surface area with one or several uniform layers.

Although the products of these coating industries appear diversified, the same basic technologies are used to produce the required coatings and films.

There is a wide range of techniques to achieve the application of the fluid on a surface in a continuous way. The choice of the method depends on several factors. Among them, it is worth mentioning the nature of the surface to cover, the liquids rheology, the solvent that is used, the dry thickness required, the cover uniformity and the velocity of the covering process.

Usually, the layer of liquid should be thin, continuous, and uniform in thickness. However, instabilities of films are observed under certain operating conditions, which can only be analyzed by considering fluid dynamics problems associated with the coating process, as nonlinear events appear in the process.

"Roll Coating" is widely used in the industry and it consists in the application of the liquid through rotating rolls.

The flows between pairs of rotating rigid rolls have been extensively studied in some systems by means of numerical methods (Samways, 1989; Meuthen, 1993; Evans *et al.*, 2004).

An important feature of roll coating is the presence of a fixed gap between the rolls, such fluid flow in the gap is the primary factor controlling the thickness and uniformity of the coated film.

Among numerous configurations, in this work, we focus on a system with two cylinders on direct rotation called "*two-roll forward coater"*.

Our goal is to characterize of this system for different spinning and gap configurations in order to build a diagram that identifies the resulting thickness for each set of parameter values in the experiment. Our results were compared with classical models to test its validity. In these systems, there may be two kinds of instabilities. At a certain velocity threshold, a hydrodynamic instability called "Ribbing instability" appears which extends smoothly across the liquid flow as a sinusoidal wave. On the other hand, when the amount of fluid dragged increases, a second instability may occur, an irregular V-shaped cross-stream wave, repeated quasiperiodically downstream (Cascade effect) appears. This last instability is particularly analyzed in this work. Once a flow field is found, its stability and disturbances must be evaluated and it is necessary to predict whether the flow will effectively displace air from the surface to be coated (Greener *et al.*, 1980; Ruschak , 1985).

In our system, a roll gets liquid continuously and a pump keeps the fluid level constant. By using more than one cylinder, it is possible to separate the supply from the application process, since the amount of liquid that can be pumped generally exceeds the required (Fig.1).

The specific design for each roll responds to operational issues. In Benjamin *et al.* (1995) a general review of different application systems is presented.

One of the main characteristics of the direct rotation fluid is the lack of dependence from the specific configuration of the rolls.

The pressure P exerted between the rolls is the key variable that controls the liquids transference in the process, while the differences in the rolls velocities adjust the applied final thickness.

Its worth mentioning that the applied pressure does not guarantee thickness control by itself because paint properties –as an example-may vary the flow across zones with an important deformation velocity due to the fluid's rheology (Varela López *et al.*, 2002; Varela López and Rosen, 2002).

In our geometry (Fig.2), the axial length of the roll is approximately 10 times its diameter, and so the gener-