# RHEOLOGICAL EFFECTS IN ROLL COATING OF PAINTS

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***Abstract*— the aim of this work is the study of the problems that arise during roll coating application of paints on steel sheets. We put in evidence the particular effects due to the non-Newtonian properties of these fluids. At speeds above a certain critical value, the flow of paint through the applicator suffers a hydrodynamical instability called ribbing, which generates a patterned interface on the film applied. Threshold of instability as well as waveform of the pattern is function of rheological properties of paints as well as surface tension. Thixotropy of paints as well as shear-thinning behaviour has been determined for several industrial paints used in the steel industry, and correlated with levelling performance after application.**

***Keywords*— coating, paint, rheology, ribbing**

## I. INTRODUCTION

Roll coating application is one of the most widely used technique for coating steel sheets, both in continuous or batch processes (Dussing and Michalika (1989), Samways (1989)). Since curing time must be as short as possible, and the coated sheet must overcome conformational processes after curing, the film applied must be thin (about 20 μm) compared to the one obtained by other coating techniques such as curtain or blade coating. Roll coating admits application of thin layers of paint at speeds high enough to satisfy industrial requirements.

However, this process presents operability limits given by hydrodynamical instabilities: above certain threshold, the film applied is no longer uniform, due to the presence of a cellular pattern at the surface (Pitts and Greiller (1961), Benkreira *et al.* (1981), Savage (1984), Rabaud and Hakim (1989)). This generates a stripped film in the direction of coating, called 'ribbing', which may or may not be flattened by surface tension before curing, depending on rheological and interfacial properties of paints used. Industrial requirements usually make necessary to operate above this threshold, and for that reason this phenomenon is not an occasional accident but an undesired part of the process.

Among many different roll configurations, we will focus our attention on the two-roll forward roll coater (Fig. 1). Pick-up roll is made of steel and it is partially submerged in a pan filled with paint. As it moves it feeds with paint the nip between this and applicator roll. The amount of paint raised by pick-up roll is a function of roller speed, immersion depth and rheological and interfacial properties of paint. This process is well described by Benjamin *et al.* (1995). After paint is lifted, is forced to pass through the nip between rollers, where an important shear stress is applied, and then paint flow is splitted into two films, one on the pick-up roll, the other covering the applicator roll's surface. This latter will be the one transferred to the steel sheet, forming a reverse meniscus during application.

Rheological properties of liquids play an important role in this process. Greener and Middleman (1975), introduces the effect of non-Newtonian viscosity and viscoelasticity on the base flow, showing the changes on pressure gradients and on coated film thickness. Sinha and Singh (1982) also studied the base flow for this geometry. Experimental results obtained for ribbing instability showed that viscoelasticity is a destabilising effect (Bauman *et al.* (1982), Fernando and Glass (1988), Dontula *et al.* (1996), Varela López *et al.* (1999, 2000)). Also changes on pattern waveform are reported (Grillet *et al.* (1999), Pauchard *et al.* (1999)). These particular features put in evidence that a correct characterisation of rheological properties of paints used in industrial con-

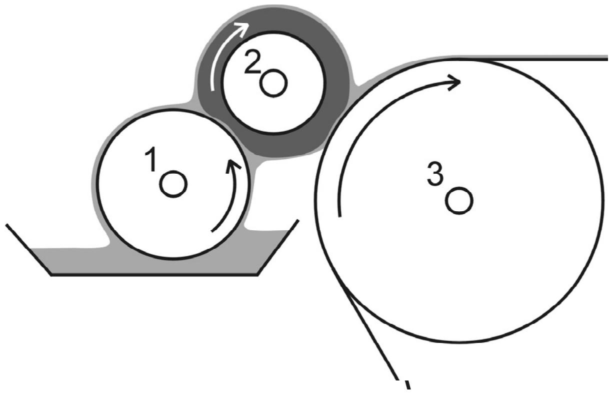


Fig. 1: Forward roll coating. (1) pick-up roll. (2) applicator roll. (3) back-up roll.