We have carried out experiences in a Hele-Shaw cell, with a radial injection at constant flow rate. A liquid, oil or glycerol solutions, pushes (or is pushed by) an aqueous polymeric solution of Xanthan. This solution is a shear thinning fluid. An oil and glycerol solution could be considering Newtonian fluids. In this type of displacement, when the mobility control parameter is greater than one, the characteristic Viscous Fingering appears. During the advance of the interface the crossover from a stable to an unstable displacement or vice versa is investigated. On the other hand, we have experimentally obtain the effective mobility of the shear thinning fluid as a function of the depth averaged velocity in order to predict the moment of transition. In the immiscible displacement case, the front becomes unstable and is finally stabilized. In this case, the non-Newtonian fluid displaces the Newtonian one. We observe that the transition occurs approximately at a critical mean velocity where the mobility control parameter reaches one. For miscible fluids, we have studied the displacement where the non-Newtonian fluid is the displacing one. In that case, the front becomes stable and finally instabilities appear. But contrary from we would expect, the critical velocity depends on the injection flow rate $Q$. As $Q$ increases, the critical velocity increases too. Our experiments seem to show that the critical velocity is fairly constant and not so sensitive to changes in the Newtonian fluid mobility.

I. INTRODUCTION

When a fluid of viscosity $\mu_2$ is injected into a fluid of higher one $\mu_1$ the phenomenon of VF is unchained. In a horizontal displacement (despising gravitational effects), instability always results when a less viscous one displaces a more viscous fluid since the less viscous fluid has the greater mobility. The mobility control parameter $\mu_1/\mu_2$ measures the relation between viscosities and when the front is unstable it becomes higher than one. In this work, a Hele-Shaw (H-S) cell is used to visualize the phenomenon. It consists of two large transparent plates separated by a distance $e$ in the order of half millimeter where the fluid is confined in a 2D geometry. Then, if the
injected fluid enters through a hole at the center of the cell, the $VF$ structure appears with a radial symmetry.

The classical displacement of a Newtonian (N) fluid in a H-S cell has received extensive theoretical and experimental investigation [1] [2] [3] [4] [5]. Numerous experimental studies have been conducted to collected data on the displacement, in an attempt to quantify the effects of different material and geometrical properties on the flow. However, the flow phenomenon with a non-Newtonian (n-N) fluid has not been very studied.

The displacement of a high-viscosity n-N fluid by a low viscosity N fluid in a H-S cell is capable of producing ramified $VF$ patterns. Experiments using polymer solutions – typical n-N fluids- showed much richer fingering patterns than those produced by N fluids [6].

Nittmann et al. [7] have first performed the fingering experiments of aqueous polymer solutions in axial and radial H-S cells, and they observed the much more ramified fingering path. As an example, Sader et al [8] pointed out about n-N effects on immiscible viscous instability in a radial H-S. This work therefore settled the point of contention regarding the role of interfacial tensions. Makino et al. [9] Also show a morphological transition from a side branching pattern to a tip splitting one with aqueous hydroxypropyl methyl cellulose (HPMC) solution pushed by air. The observed morphology transition was correlated with the dimension of the fingering pattern. Van Damme in Ref [10] has shown the patterns obtained by displacing an aqueous colloidal clay suspension by air. It was pointed out there that a fractal behavior is obtained only by increasing the n-N character of the colloidal fluid. When that once sufficient n-N character has been obtained, lowering the interfacial tension by using miscible fluids he has indicated Thad does not introduce major changes in the geometry of the patterns. The boundary fractal dimension is basically unchanged, but the average finger width is smaller.

Zhao et al [11] [12] presented the VF problem for an N fluid that pushes an n-N fluid in the miscible case. In this work pattern formation is studied by injecting water into a radial H-S cell filled with an aqueous solution hydrophobically terminated polyxythylene. A crossover form a fingering to a fracturing pattern is observed when the injection rate exceeds a threshold value. Despite the strong variation of patterns as four control parameters are independently varied (injection rate, molecular weight, gap