EXPERIMENTAL INVESTIGATIONS ON A LIQUID FLOW IN A CHANNEL PROVIDED OF POROUS OBSTACLES

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I – Introduction

The objective of the present work is to perform an experimental study of the evolution of a fluid in a channel provided with porous obstacles.
Many studies related to this kind of problems have increased significantly during last years. This interest is due to the fact that these last decades, an increasing number of engineering processes are developed with use of porous media. The domains of application are very numerous and one can mention geothermal systems, the hydrogeology, enhanced oil recovery, packed bed chemical reactors and environment.
In fact, the present survey wishes to be a validation, as much as possible, of the numerous theoretical studies previously performed.

II – Experimental procedure

The characterisation of the flows within the porous media was, up to here, achieved by means of four main experimental techniques: the visualisation of the flow after injection of a filament of dye, the analysis of the fluctuations of velocity gradients within the porous medium by using an electrochemical method, and the measure, by laser velocimetry or hot wire technique, of the velocity field.
Thus, WEGNER and al. [1] studied the flow through a dense cubic bed of spheres, in a square section column. The technique of visualisation with dye filaments is used. The observed flow is very complex, with the presence of whirling regions and the apparition of instabilities for Reynolds numbers comprised between 90 and 120. LATIFI et al. [2] and RODE et al. [3] explored the flow in a bed of spheres, with the electrochemical micro-probes implantation in the porous network. They have, particularly, determined the mean and maximal sizes of the whirling in the flow
The present work is therefore a contribution to the description flow of a fluid, in this case the water, in a channel which is provided of porous obstacles on its bottom wall. It has been proceeded to the constitution of a cartography of the velocity field. The measurement of pressure drop through the porous obstacles is also carried out. It permitted, among others, to verify the law of variation of the pressure gradient versus to the velocity, for flows with non negligible inertial effect (Darcy-Forchheimer extended model).
The measures have been done on a bench constituted of a channel in PVC (40x150mm of section and 1000mm of length). The channel is associated to a water tank, functioning in closed circuit with the help of a pump. Parallelepipedic porous obstacles constituted of a cubic arrangement of small balls (8mm of diameter) with a porosity of 0.5 have been achieved and fixed on the basis of the channel. The dimensions and positioning of the three chosen obstacles have been fixed in order to be able to make a comparison, at least qualitative, between the present results and those obtained in previous numerical studies [4].

The experiment consisted therefore in measures of velocities, by laser velocimetry, and of losses of pressure, by holding of manometric heights, in different sections of the flow, since the entry of the channel until the downstream of the obstacles, while passing by the whirling zones situated between the porous blocks.

III – Results

The figure 1 gives an example of velocity profiles obtained by the laser velocimetry for a Reynolds number Re=2350. The plotted values concern the zone of fluid situated between the first and the second obstacle. One notices particularly the presence of negative velocities which certainly traduce the existence of whirling zones forming themselves in these spaces.

The figure 2 as for her, give an illustration of the evolution of the pressure drop ($\Delta P/L$) between the upstream and the downstream of the first obstacle, according to the filtration velocity U, This curve can be correlated by a polynomial relation of order 2 under the following shape :

$$(\Delta P/L) = AU^2 + BU$$

This law is quite in agreement with the prediction of the Darcy-Forchheimer model. In fact, the different obtained results show globally less than 15% of difference with results obtained with relationships proposed by other authors [5].

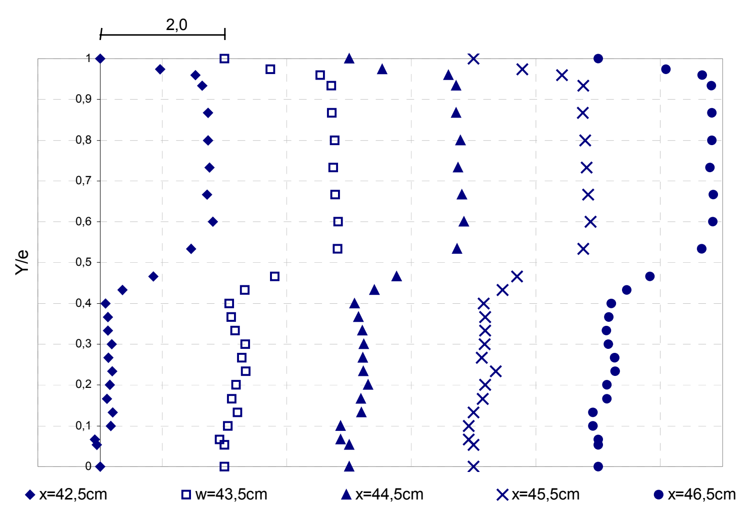

Figure 1: Velocity profile in the first recirculation zone Re=2350

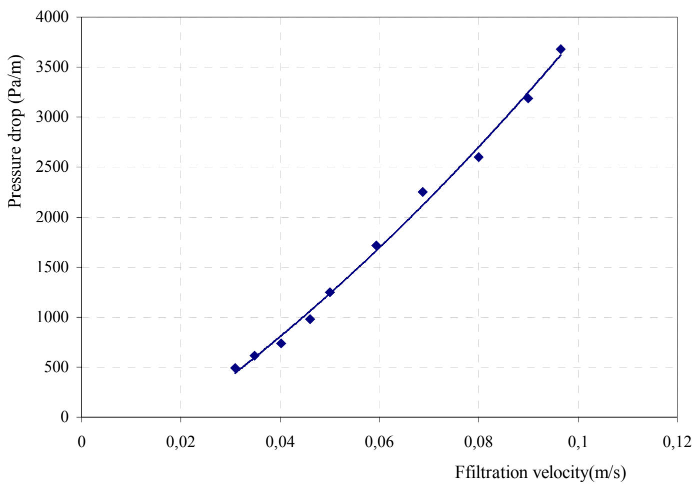

Figure 2: Pressure drop between the inlet and the outlet of the first obstacle, versus the filtration velocity.

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Key words : Channel, Liquid flow, Porous obstacles, Experimental study