May 21, 2020

1 Presentation of the test case

this study will be based on laminar flow around a step laid in a flat channel. The fluid is subjected to a sudden widening that causes an inverse pressure gradient where the flow separates into several zones, among which a recirculation zone is formed, noted x_r, where the flow closes to return to the step. The Reynolds number denoted Re for this flow is calculated from the channel height S, the average flow velocity U_{ave} and the kinematic viscosity υ, and is defined by:

$$Re = \frac{SU_{ave}}{\upsilon}$$

and as $\upsilon = \frac{\mu}{\rho}$ so :

$$Re = \frac{S\rho U_{ave}}{\mu}$$

When the flow has low Reynolds number values it is said to be stationary, while flows with higher Reynolds number values become unsteady and the average length of the recirculation zone decreases until reaching a constant saturation value, in this project we will only be interested in the unsteady case for two different Rynolds number values $Re = 389$ and $Re = 1095$.

The computational domain Ω is a channel with a descending step as shown in the figure below.

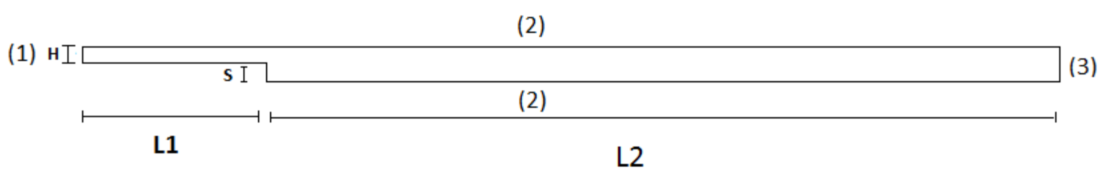

Figure 1: Calculation area.

The Data provided on the whole Ω domain allows us to have conditions at the specified limits, the tables below summarize these data.

Name	Description	Nominal Value	Units
L1	Length of the upstream section	2e-1	m
L2	Length of the downstream section	5e-2	m
S	Step height	4.9e-3	m
H	Inlet channel height	5.2e-3	m
U_{int}	Initial velocity	-	m/s
U_{ave}	Average velocity	-	m/s

Table 1: Geometric data

Name	Description	Nominal Value	Units
ρ	density	1.23	Kg/m^3
μ	dynamic viscosity	1.79e-5	$Pa.s$
ν	viscosité cinématique	1.4553e-5	m^2/s

Table 2: Physical data

In this study 3 boundary conditions are imposed:

1. On boundary (1) a Poiseuille profile is placed as an entry condition, it is defined by:

$$u = U_{int} = 6U_{ave}(\frac{y_1}{H})(1 - \frac{y_1}{H}) \tag{1}$$

such as:

$$y1 = y - S$$

and U_{ave} are derived from the selected Reynolds number as:

$$U_{ave} = \frac{\nu Re}{S} = \frac{\mu Re}{\rho S}$$

The profile of Poiseuille at the entrance is represented by the graphs below:

(a) Pour Re = 389:

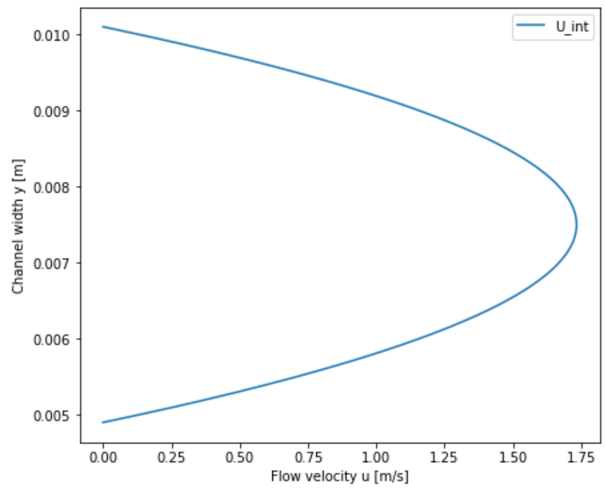

Figure 2: Profile of Poiseuille at the entrance for Re=389

(b) Pour Re = 1095

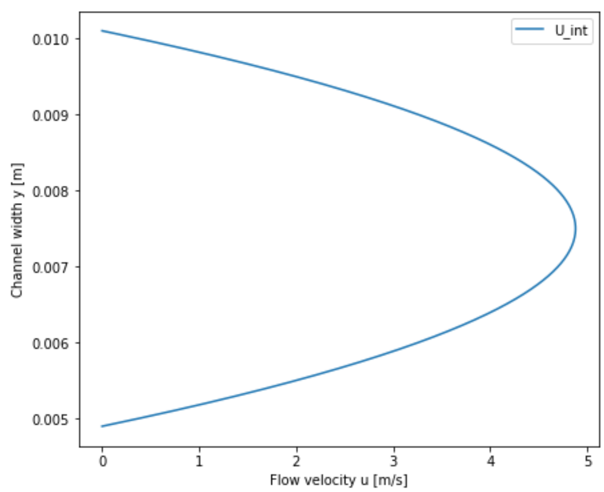

Figure 3: Profile of Poiseuille at the entrance for Re=1095

2. On the limits (2), i.e. on the upper and lower wall we have

$$u = 0 \tag{2}$$

3. On boundary (3) the exit boundary condition is free, which means that no constraint is imposed on the exit boundary.

To study the laminar flow around a descending step we have devised the geometry [Figure 1] in conformal blocks as the figure below illustrates :

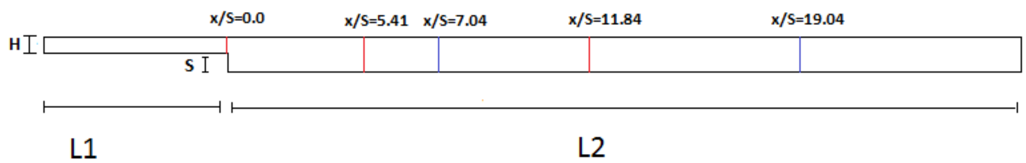

Figure 4: Splitting the Ω domain into conformal blocks

The study will be based on the flow velocity profile for Re = 389 and Re = 1095 on different vertical x_r/S lines shown in the figure above.