ON THE DESIGN OF COEXTRUSION DIES FOR POLYMERIC MULTILAYER PRODUCTS

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INTRODUCTION

- Multilayer films allow combining properties of different materials in a synergic way.
- Multilayer films are manufactured by coextrusion.
- Starting from 2 layers (AB), using an Interfacial Surface Generator (ISG), shown in Figure 1, the number of layers are duplicated (ABAB).
- Each ISG comprises different Geometrical Transformations (GTs).
- Combining GTs allow reducing the size and power consumption in a ISG.
- However the combination of GTs should not affect the envisaged layer distribution.
- The main aim of this work is to increase the knowledge concerning the design of ISGs.

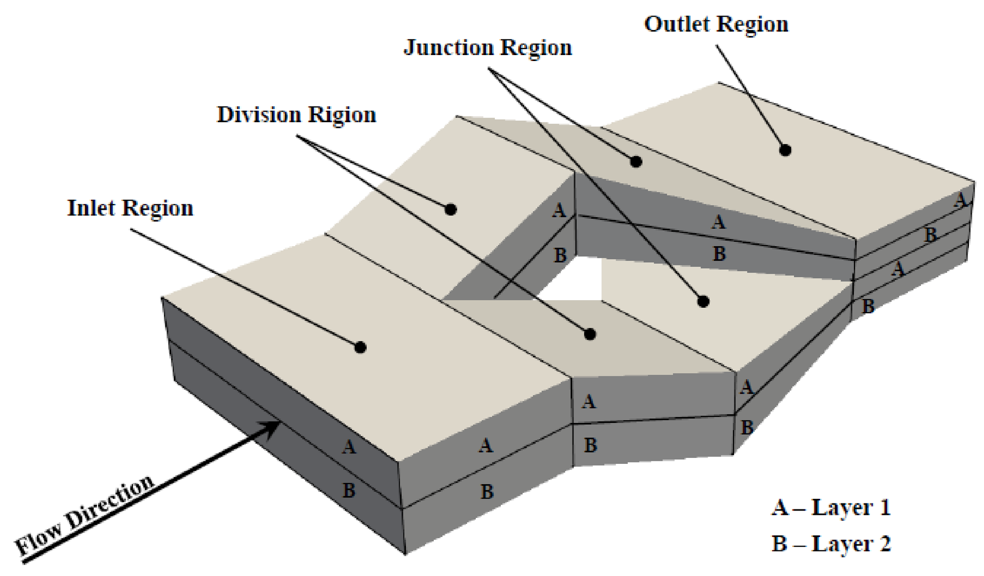


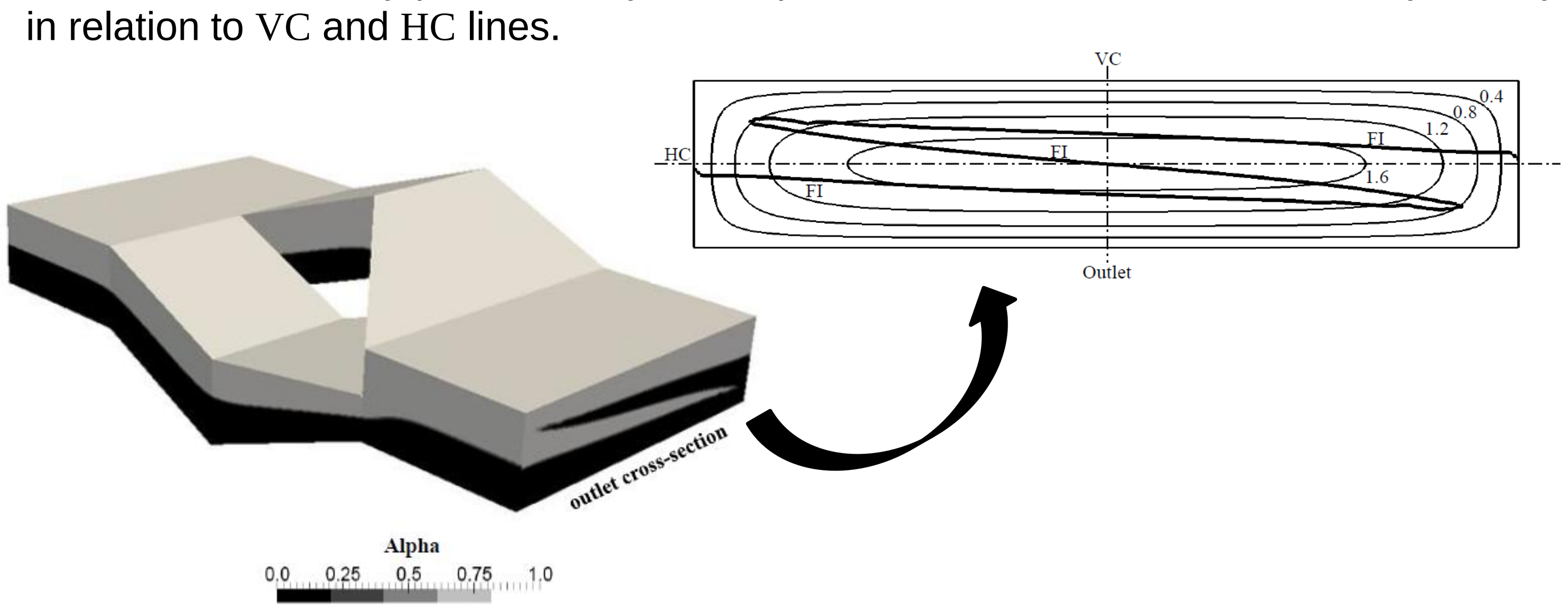
Figure 1. Interfacial surface generator module.

COMPUTATIONAL FRAMEWORK

- The simulation was performed by the multiphase solver interFoam in OpenFOAM.
- This solver uses a free-surface capturing model based on the volume-of-fluid (VOF).
- In VOF, the transport equation for an indicator function, representing the volume fraction (α) of one phase, is solved simultaneously with the continuity and linear momentum balance equations [3].
- For the rheological constitutive equation the Newtonian fluid model is employed.
- The pressure-velocity coupling is acomplished using the PIMPLE algorithm [4].
- The boundary conditions are illustrated in Figure 4 and described in Table 1.

DOOLEY'S ISG

- The polymer behavior flow in the ISG concept proposed by Dooley [2] was evaluated to determine its influence in the uniformity of the layers.
- The geometry of the case study is illustrated in Figure 1.
- The polymers properties are listed in Table 2.
- The mesh, defined after a mesh sensitivity analysis, comprises 2,003,302 cells.
- Figure 2(a) shows the polymeric layers distribution at the flow channel outlet, which is uneven distribution.
- Figure 2(b) shows the velocity isolines normalized with average velocity and the polymer interface (FI) line.
- The results confirm the uneven polymeric layers distribution at the flow channel outlet, for the velocity profile is fully developed, as can be concluded from its symmetry in relation to VC and HC lines.



(a) (b)

Figure 2. Dooley's ISG results. (a) Phase fraction. (b) Normalized velocity and interface contours.

- Aiming to understand and define appropriate design guidelines for ISGs, the Dooley's concept was analyzed in detail.
- The flow channel geometry comprises different unit geometrical transformations (GTs).
- Figure 3 shows a breakdown of these GTs classified in relation to the mode (Lateral, Vertical and Convergence) and number of simultaneous transformations.
- This allowed the definition of a parameterized GT, that may represent all the possibilities, shown in Figure 4.

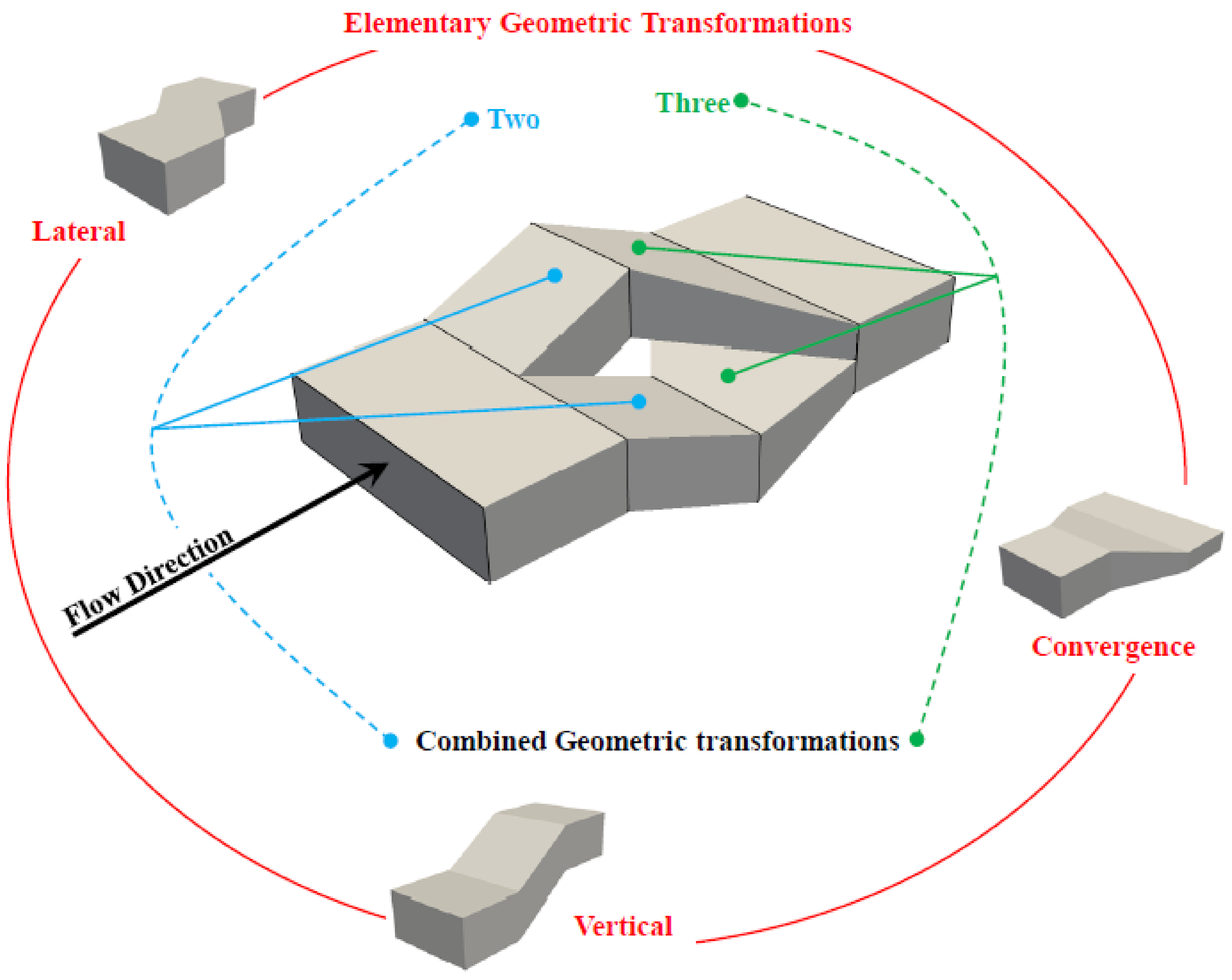


Figure 3. GTs present on Dooley's ISG die.

CASES STUDIES

- Figure 4 illustrates the parameterized module and the specific case studies comprising one GT, two and three simultaneously GTs.
- In this work just two modules (GT_C and GT_VC) were evaluated to verify its impact on the layers uniformity.

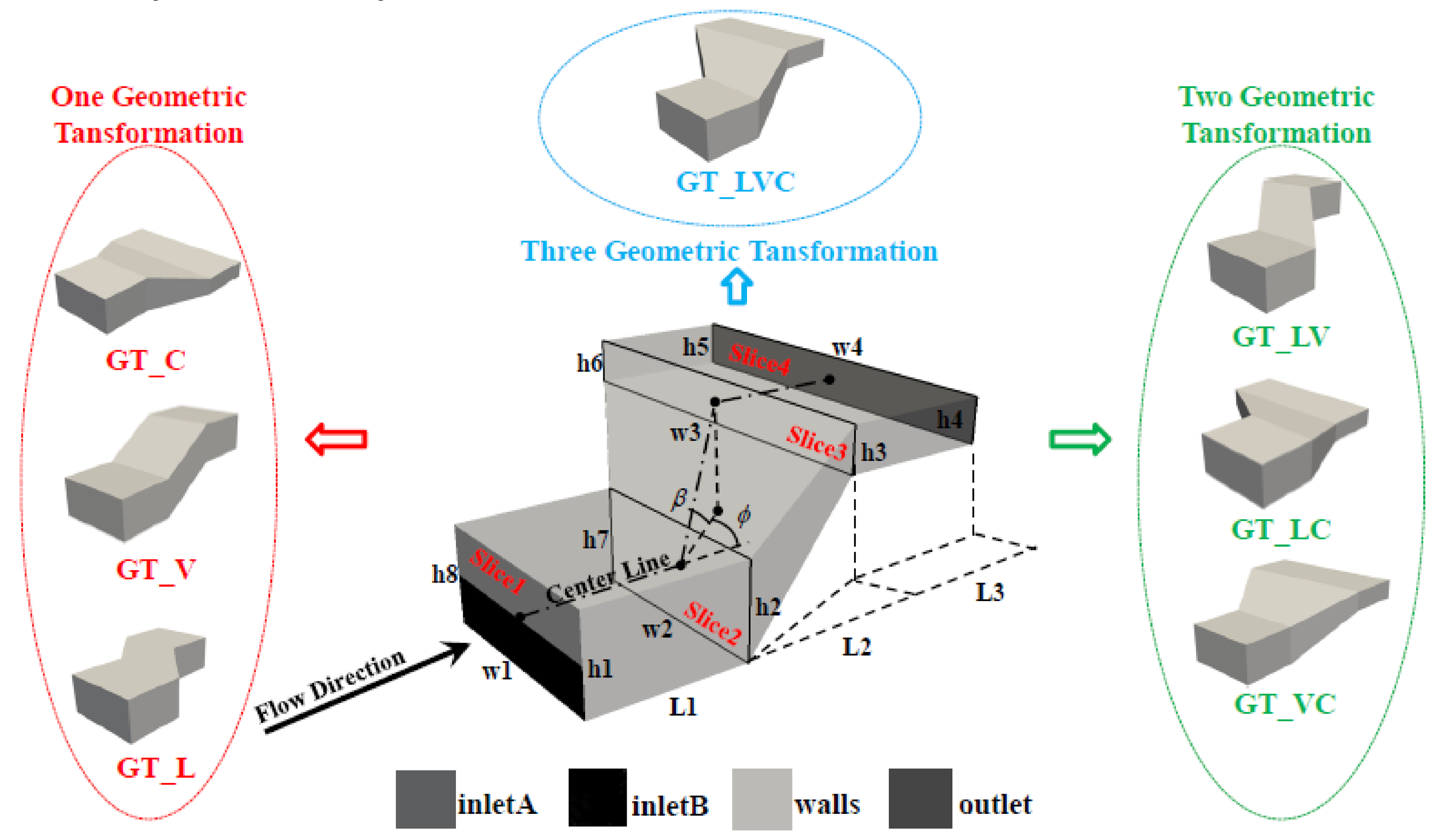


Figure 4. All GTs identified and base geometry to be used on the GT study.

Table 1. Boundary conditions.

Patch	U (m/s)	p (Pa)	α
inlet_1	(0 0 0.1)	null normal gradient	0
inlet_2	(0 0 0.1)	null normal gradient	1
walls	no-slip	null normal gradient	null normal gradient
outlet	null normal gradient	0	null normal gradient

Table 2. Polymers Properties.

Property		Value
Density	ρ (kg/m^3)	1000
Kinematic Viscosity	η/ρ (m^2/s)	0.577

RESULTS AND DISCUSSION

- Figure 5 shows the results obtained for GT_C.
- For GT_C in Slices 3 and 4 (shown in Figure 4), the thickness of the polymeric layers are uniform, which can be confirmed from the FI and HC lines.
- The velocity contour profile is symmetrical with respect to the VC and HC lines.
- Slice4 shows only a reorganization of the velocity profile contours and even layers.

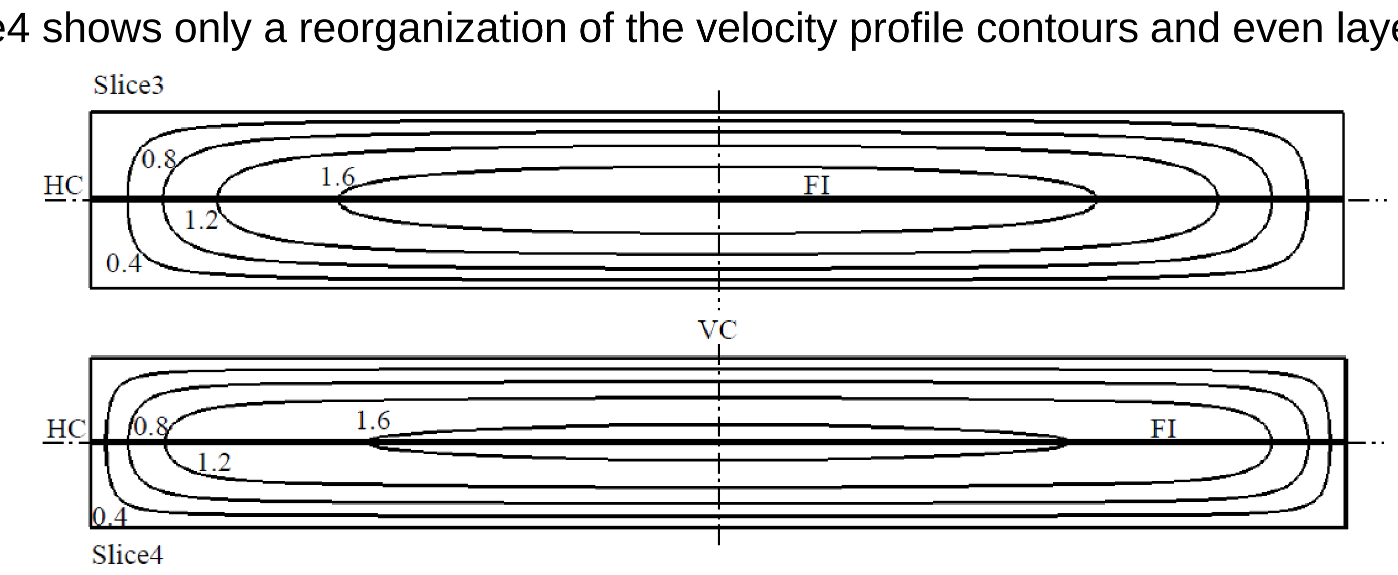


Figure 5. GT_C.

- Figure 6 shows the results obtained for GT_VC.
- In Slice3 the velocity contour is unsymmetrical and the polymeric layers present a slightly uneven distribution.
- In Slice4 we can see that the velocity profile was rearranged, reaching a fully developed state. However, the problems of the layers distribution remain.

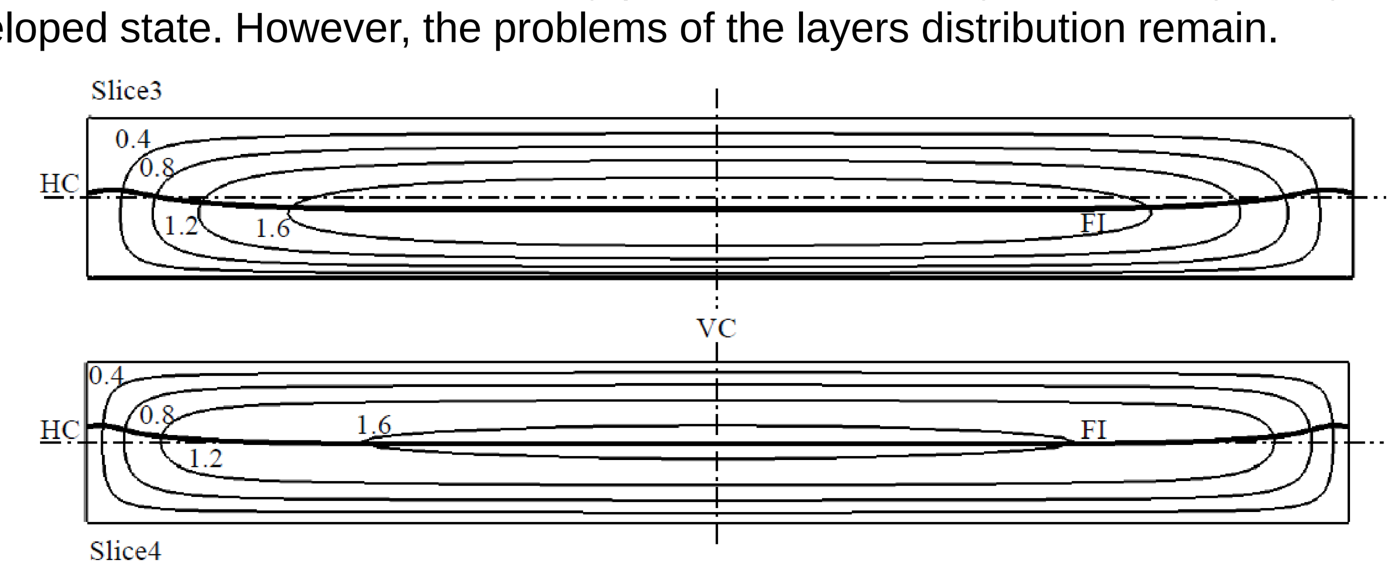


Figure 6. GT_VC.

CONCLUSIONS

- The simultaneous combination of specific GTs might have a negative impact on the uniformity of the polymer layer thickness distribution in ISG's.
- This study must be enlarged to all the possible ISG modules.
- The information collected on the overall study can be used to guide the design of duplicators, capable of producing coextruded parts with uniform layer distribution.

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