Comparisons between an injector block and a multi-manifold die (MMD) using Computational Fluid Dynamics (CFD)

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Polyester based multi-layered films (MLFs) have applications including touch screens, food packaging and data storage media [1]. An MLF is formed when different low Reynolds number polymer melt flows come together for the first time in either: i) an injector block linked to a die or ii) a multi-manifold die (MMD) [2-4]. The process of combining melt layers is known as *coextrusion*. The use of coextruded products allow for desired polymer properties to be combined into one structure [5]. There are also financial benefits to coextrusion [6].

In i) the different layers coexist in the same flow channel within the injector block. The (end fed or centre fed) die is then used to convert the circular shaped unified melt structure into a thin rectangular melt curtain of uniform thickness. In ii) the layers are first spread across the whole MMD before coming into contact [3]. The MMD effectively acts as a combination of an injector block and a die. Independent of whether system i) or ii) is used, the melt curtain is then rapidly cooled below its glass transition temperature using a casting drum, before being stretched in both the forwards and sideways directions [7]. This produces the final biaxially oriented stable MLF.

The choice between i) and ii) depends on factors such as: the viscosity ratio between different polymer melts, the secondary layer thickness and the melt pipe and extruder temperatures. The principal advantage of system ii) is the ability to handle a wider range of melt viscosity ratios than i) [2-4]. This is due to the melt layers being in contact for a significantly shorter time period in ii). An approximate viscosity ratio limit when using i) is between 2:1 and 4:1 [2, 4]. The major advantages of using i) include simplicity, cost and greater flexibility than ii) in terms of the number of layers and layer thicknesses [2, 3]. It is estimated in [3] that over 95% of flat-die coextrusion systems use process i).

The accompanying presentation contains comparisons between systems i) and ii) using CFD. The finite volume based CFD package STAR-CCM+ is used to model the flow of polyester melts in pilot scale geometries typical of DuPont Teijin Films (DTF) operation. The end fed die and MMD are of identical width and an ABA MLF is modelled. Here A and B are different polymer layers. The volume of fluid (VOF [8]) method captures and tracks the polymer-polymer interface effectively. The numerically predicted ability of each system to handle increasing secondary layer viscosities is addressed.

Figure 1 shows the progressive volume fraction through a) an injector block and b) a 410 mm wide end fed die, where Melt 1 is shown in red and Melt 2 in blue. The smooth interface is a result of the VOF method and a fine mesh in regions of importance. Planned future project work includes extending both systems i) and ii) to industrial scale models and experimentally validating modelling results.

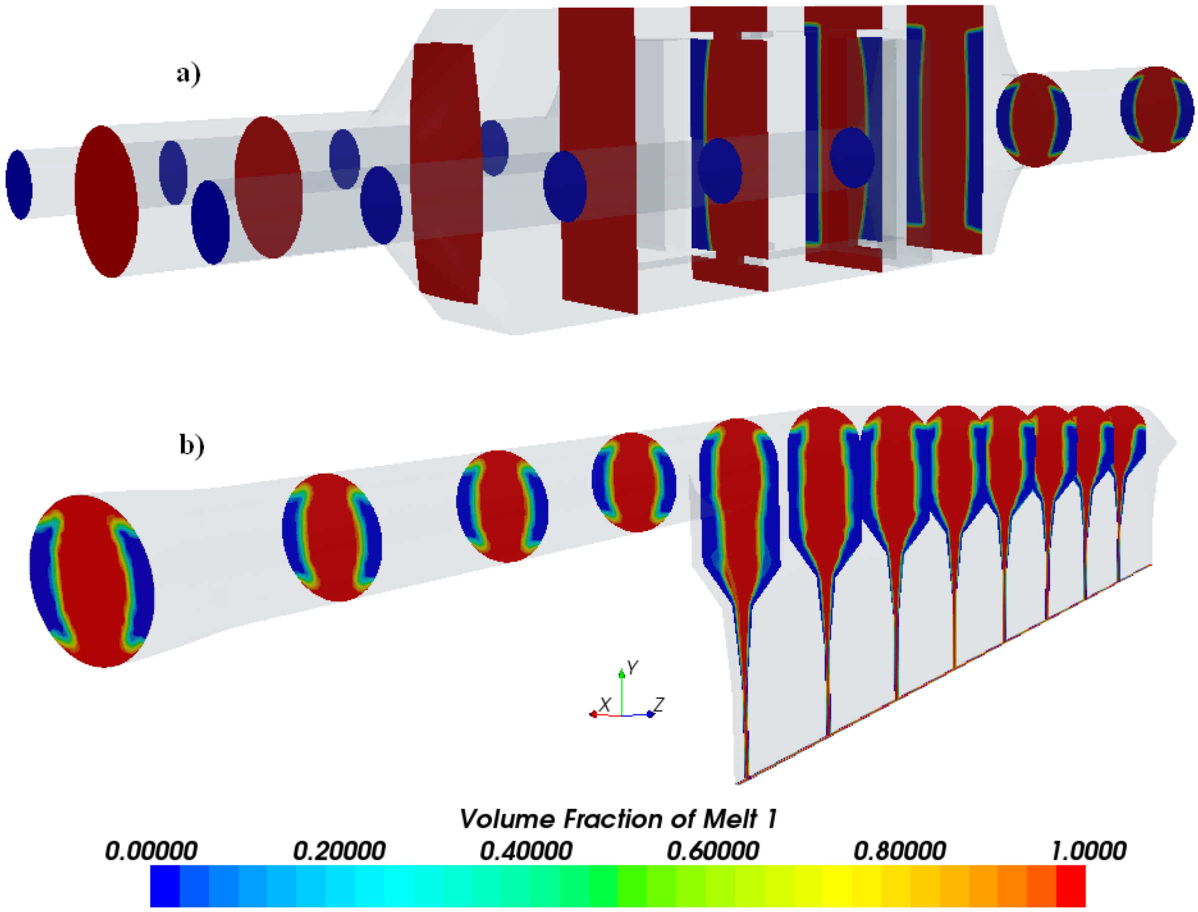

Figure 1: Plots showing the progressive volume fraction through a) an injector block and b) a 410 mm wide end fed die. Flow direction is from left to right.

References

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