Electronic Supplementary Material (ESI) for RSC Advances.

Simultaneous improvement of strength and toughness in fiber reinforced isotactic polypropylene composites by shear flow and β-nucleating agent

Yan-Hui Chen [a], Zhang-Yong Huang [b], Zhong-Ming Li [a,*], Jian-Hua Tang [b], Benjamin S. Hsiao [c,*]

[a] *College of Polymer Science and Engineering and State Key Laboratory of Polymer Materials Engineering, Sichuan University, Chengdu 610065, China*

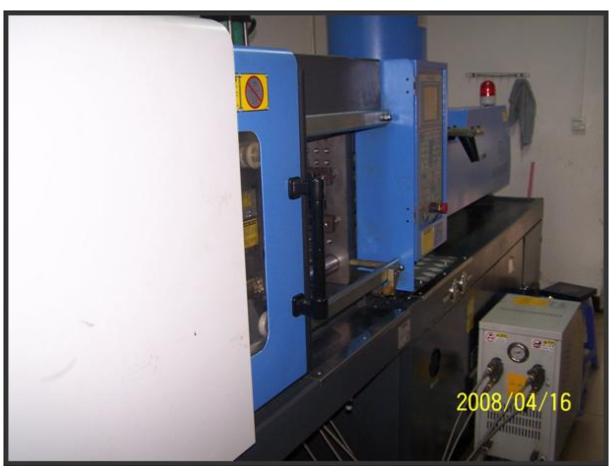
[b] *College of Chemical Engineering, Sichuan University, Chengdu 610065, China*

[c] *Department of Chemistry, Stony Brook University, Stony Brook, New York 11794-3400, USA*

Supporting Information

Oscillation shear injection molding (OSIM)

Fig. 1 shows the overall picture for oscillation shear injection molding (OSIM) machine, and Fig. 2 shows the local picture for the mold with an oscillation shear supplier. The critical point is its mold, whose 3D schematic illustration is shown in Fig. 3. Fig. 4 presents an explanatory cartoon to demonstrate how the mold with an oscillation shear supplier works. The primary feature is that the hot melt is subjected to high pulse shear stress in the mold, which is given by two pistons moved reversibly at the same frequency.



Corresponding author. Tel./fax: +86 28 85406866.
E-mail address: zmli@scu.edu.cn
Corresponding author. Tel./fax: +1 631 632 7793.
E-mail address: bhsiao@notes.cc.sunysb.edu;

Fig. 1. Overall picture for oscillation shear injection molding (OSIM) machine.

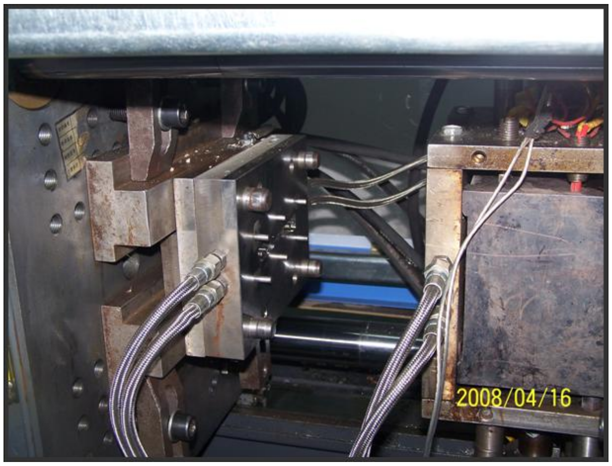


Fig.2. Local picture for the mold with an oscillation shear supplier.

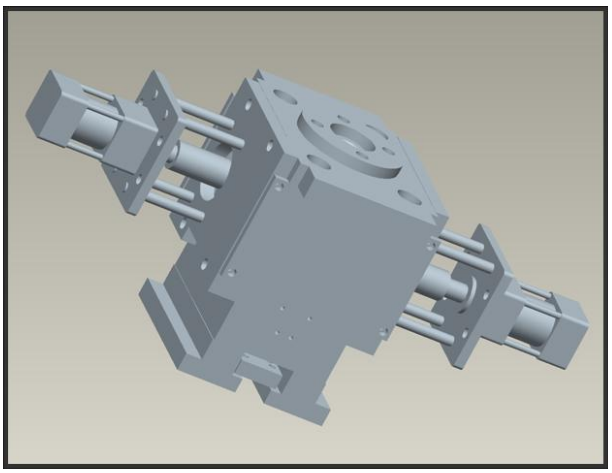
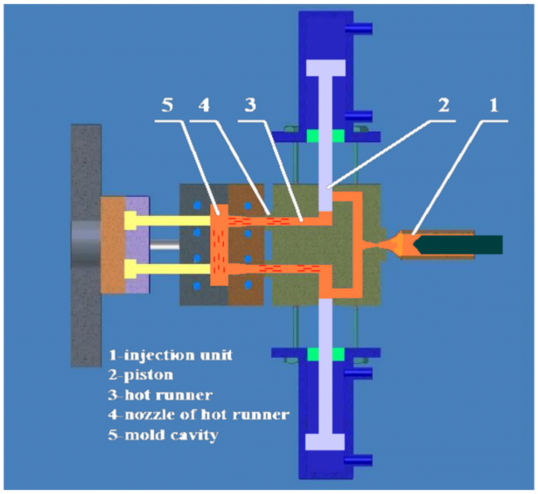


Fig. 3. 3D schematic illustration for the mold with an oscillation shear supplier.



(http://v.youku.com/v_show/id_XNjcxNzE0MjM2.html)

Fig. 4. Cartoon illustration for detailed work process of the mold with an oscillation shear supplier.

Estimation of the shear rate provided by oscillation shear injection molding (OSIM)

In order to calculate the shear rate provided by OSIM technique, the formation process of the OSIM sample in the mold should be clear first. After the melt was injected into the mold, a thin surface layer was formed. At the packing stage, the melt was gradually frozen and formed each layer upon a high shear stress given by the reversely moving piston. According to the actual cross-section of the OSIM sample, the schematic shape of each layer in the OSIM sample was displayed in Fig. 5. It is observed that layer shape gradually transforms from rectangle to oval and finally to round (radius=1mm). The flow channel of the melt shrinks so that the shear rate gets stronger until the gate is frozen. The shear rate between the thin surface layer and skin layer is the lowest, while the shear rate between the intermediate and core layer highest.

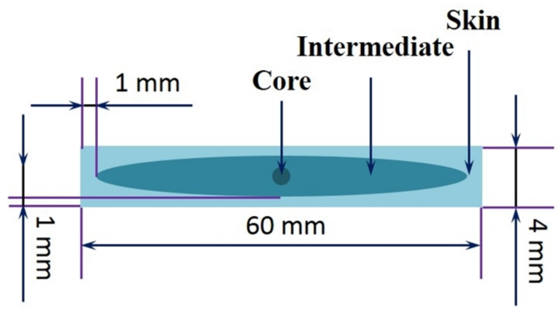


Fig. 5. Schematic shape of each layer (skin belongs to outer layer; intermediate and core belong to inner layer) in the OSIM sample.

Since the moving speed of pistons in the injection molding processing (refer to Figure R1) is constant, the volume flow rate of the melt (Q) is thus constant. Specifically, the diameter of the piston is 25 mm, the working distance is 50 mm and each moving cycle needs 3 s. Therefore, Q is equal to 8181.25 mm^3/s.

The shear rate ($\dot{\gamma}$) in the rectangular flow channel (minimum) can be roughly calculated as follows (R1). The shear rate in the round flow channel (maximum) can be roughly calculated as follows (R2).

$$\dot{\gamma} = \frac{(4n+2)Q}{nwh^2} \qquad \text{(R1)}$$

$$\dot{\gamma} = \frac{(3n+1)Q}{n\pi R^3} \qquad \text{(R2)}$$

where n is the non-Newtonian index, Q is the volume flow rate, w is the width of the OSIM sample, h is the length of the OSIM sample, R is the radius of the flow channel. Since n is correlated with the shear rate, we adopt 0.4 as an average value. After approximate calculation, $\dot{\gamma}_{\min}$ = 5.11 s^{-1} and $\dot{\gamma}_{\max}$ =14322.92 s^{-1}. It is seen that the shear rate changes dramatically from the skin to core layer. Therefore, we made a conclusion that the shear rate is over hundreds of s^{-1} in our manuscript based on its average value. We put this calculation method in the revised supplement information and modified the description in the revised manuscript.