Predictive modelling of film blowing: A 1-D approach

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Predictive modelling of film blowing: A 1-D approach

H. Mercan, P. D. Anderson, G.W.M. Peters

Introduction

Film blowing is an important process for the manufacturing of thin bi-axially stretched films (Fig.1). The objective of this study is to develop a 1-D model for film blowing process and compare the response of two different linear low density polyethylene’s (Enable and Exceed) under realistic experimental conditions.

The relaxation time of Enable is 20 times larger than Exceed. In crystallization kinematics the number of spheroids of Enable is 50 times bigger than Exceed however the growth rate is 4 times slower 2.

\[ \lambda_{\text{Enable}} = 20 \times \lambda_{\text{Exceed}} \]
\[ N_{\max, \text{Enable}} = 50 \times N_{\max, \text{Exceed}} \]
\[ G_{\max, \text{Exceed}} = 4 \times G_{\max, \text{Enable}} \]

Objectives and improvements:
1. 1-D model: assumptions from literature
2. new crystallization model 3
3. comparison of simulations for our materials

Comparison with literature

Figure 2. 1-D PTT full model with thermal and crystallinity effects are included, (a) Comparison of the bubble radius with experiments of Buttler *, (b) Comparison of the film thickness with the experiments of Buttler *.

Table 1. Realistic Experimental Process Conditions for Enable and Exceed

<table>
<thead>
<tr>
<th></th>
<th>Enable</th>
<th>Exceed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial radius, ( r_0 ) (mm)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Initial thickness, ( h_0 ) (mm)</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Blow-up ratio</td>
<td>1.76</td>
<td>1.87</td>
</tr>
<tr>
<td>Draw-ratio</td>
<td>21.29</td>
<td>16.26</td>
</tr>
<tr>
<td>Freeze-line height (mm)</td>
<td>71</td>
<td>75</td>
</tr>
</tbody>
</table>

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Results

Figure 3. 1-D simulations for Film blowing process, comparison of Exceed and Enable, (a) Bubble radius, (b) Film velocity, (c) Space filling, (d) Temperature, (e) Normal stress in machine direction (f) Normal stress in circumferential direction.

Conclusions

Enable cools down and reaches the maximum space filling value earlier than Exceed. This is due to a low take-up velocity which is a consequence of the higher relaxation time. The maximum stress ratio of Enable is bigger than Exceed. \([\sigma_{11,\max}/\sigma_{33,\max}]_{\text{Enable}} = 8.3085 \text{ and } [\sigma_{11,\max}/\sigma_{33,\max}]_{\text{Exceed}} = 5.6239\].

References

2. M. van Drongelen, G.W.M. Peters, Unpublished experimental study