ExxonMobil

Processing guide for thin films

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Fine tuning for optimum processing

Exceed™ XP performance polymers have good processability performance and can be readily processed on modern extrusion equipment. However, it is important to understand that some of our Exceed XP grades have a unique performance / orientation dependence and are more responsive to processing parameters.

Unlike most other resins, increasing the strain rate orientation in the machine direction (MD) can have a significant positive impact on the film MD tear strength as show in Figure 1 below. Addition of linear polyethylene resins up to 30% can maintain MD tear properties, but the addition of long-chain branched LDPEs has a negative impact.

Other film properties are not strongly influenced by orientation except under highly orienting conditions.

Figure 1:
Presents MD tear strength data for a range of film thicknesses from 20 microns up to 75 microns. The thicker gauge films have lower strain rate (STR) and the thinner gauge films have higher STR.

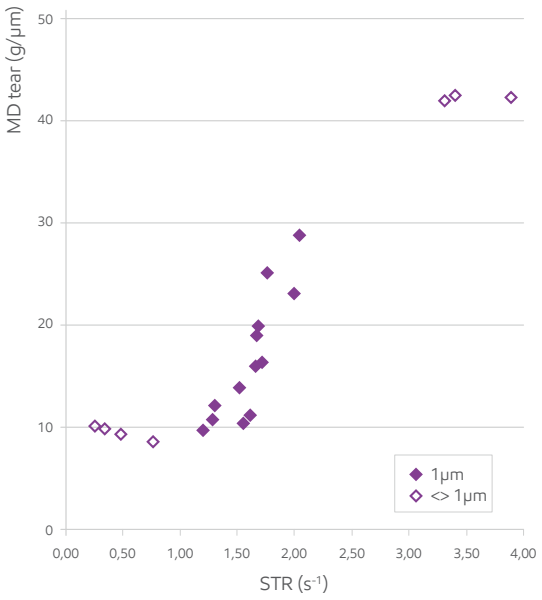
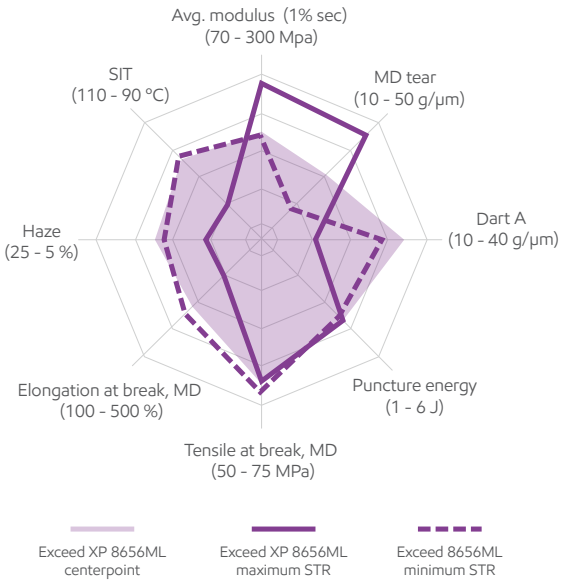


Figure 2:
Presents data from a thin film (gauge) produced at very high output rates and efficient cooling to represent the most severe effects on film properties. MD tear is most affected within the range of typical commercial operating conditions.



when eXtreme Performance matters

Typically strain rate is used to estimate the degree of machine direction orientation. Strain rate is a function of extrusion parameters including output rate, frost line height, film gauge, blow-up ratio (BUR) and die gap. Below is a directional table highlighting the effect of various processing variables on strain rate.

Increasing parameter	Output	Frost line	Film gauge	BUR	Die gap
Strain rate	▲	▼	▼	▼	▲

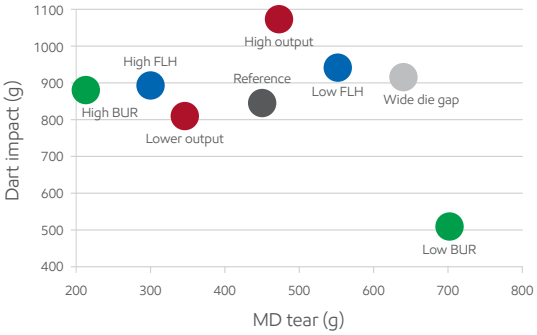
The most favorable processing conditions are

- high output rates (> 0.6 kg/h/mm die diameter or > 11 lbs/h/die inch circumference)
- efficient cooling (chilled air, including IBC) to minimize frostline height
- greater drawdown ratios (thin films)
- wider die gap (1.5 to 2.5 mm or 60 to 100 inch)

Orientation effects are most apparent when producing films less than 2.5 microns. Thicker films require process conditions that typically do not achieve the high strain rates necessary for high orientation. Using lower work screw designs in combination with highly efficient bubble cooling offer the greatest potential to improve performance.

A designed experiment has been conducted to better understand the individual impact of these process parameters on the Exceed™ XP performance polymers products. The experiments were conducted by starting with a reference condition and then change one process condition at a time to explore the experimental space. Figure 3 presents results using Exceed XP 8656, a 0.5 MI, 0.916 density grade. The trial was conducted on a modern film extrusion line with efficient IBC cooling.

Figure 3: Exceed XP 8656



1 mil / 25 µm film made from Exceed 8656ML performance polymer on a 90 mm groove feed extruder with film line varying process conditions around 'Reference' (2.5 BUR / 11.5 cm FLH / 1.5 mm die gap / 1 kg/hr/mm output) conditions.

Process parameter ranges used in the study are:

Output rate: 0.6 and 1.2 kg/h/mm die diameter
Die gap: 1.5 mm to 2.3 mm
BUR: 2.0 to 3.0
Frost line height: 100 to 125 cm

Additional studies were conducted in a blown film line without IBC capability. The effect of orientation is still apparent with the output rate held constant at 0.6 kg/hr/mm diameter for the 0.5 MI products, Exceed XP 8656 and 8358.

Figure 4: Exceed XP 8656ML

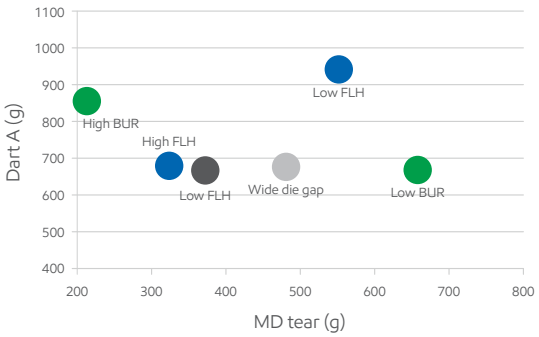


Figure 5: Exceed XP 8358ML

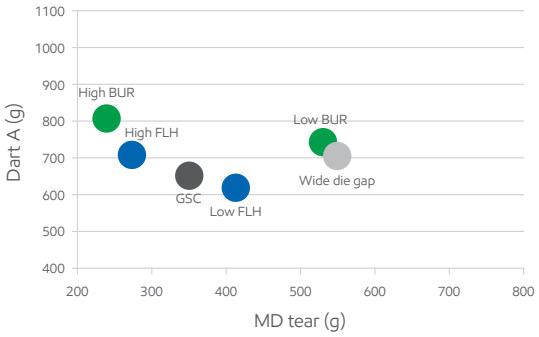
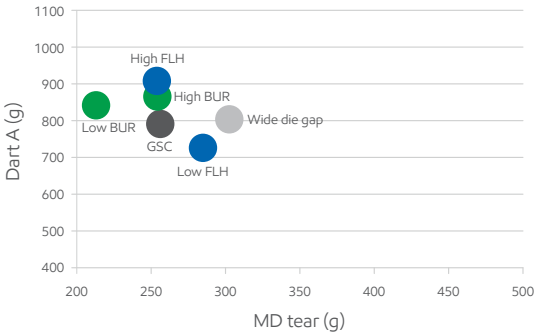


Figure 6 presents data from Exceed XP 8318. The lower molecular weight of this product (MI=1) does not show the boost in MD tear exhibited by the other grades although the dart impact is high and relatively unaffected by the process parameters.

Figure 6: Exceed XP 8318ML



Extrusion line conditions are typical for LLDPE products since the rheology is quite similar. The 0.5 MI products are typical for fractional melt index (FMI) products and generally process at higher pressures. Melt temperature can be increased to compensate. Higher melt temperatures though will result in a higher frost line and effect MD tear primarily.

Data traceability: BCT201504.0199 and BCT201506.0413-01

Test	Test method
MI (Melt index)	ASTM D-1238
Density	ASTM D-4703 and ASTM D-1505 / ISO 1183
Tensile tests	ASTM D-882
Dart impact	ASTM D-1709 (procedure A)
Elmendorf tear	ASTM D 1922-09
Puncture	EMC method (method B)
Seal strength	EMC method
Hot-tack	ASTM F-1921
Haze	ASTM D-1003

Exceed™ XP performance polymers — when eXtreme Performance matters.

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