Gradus Vol 4, No 2 (2017) 357-362
ISSN 2064-8014

EFFECT OF FILM BLOWING PARAMETERS ON TENSILE STRENGTH

Dorottya Nagy [1*]

[1] John von Neumann University, Department of Materials Technology, Kecskemét, Hungary

Keywords:
film blowing
polyethylene
tensile strength
orientation
processing parameters

Article history:
Beérkezett: 18 September 2017
Átdolgozva: 11 October 2017
Elfogadva: 25 October 2017

Abstract
In this study polyethylene film was made while some of the film blowing parameters were changed. These parameters were the extruder speed, rolling speed and film diameter. From the films samples were cut in two directions (parallel and perpendicular to the rolling direction), then tensile strength and geometric properties were examined. These measurements are appropriate to confirm the orientation process and to show the effect of the parameters. The fact that extruder and rolling speed influence geometric sizes, was revealed. Generally, the extruder or rolling speed raises film width and reduces film thickness. Also processing diameter has a similar effect for these properties. Extruder or rolling speed increases, while diameter demolishes tensile strength. However, these curves do not show linear behavior. The phenomenon of orientation was confirmed, while usually the parallel samples have the highest tensile strength.

1 Introduction

Polyethylene is one of the most used polymers in packaging technology. Many types of films and bags are made from this simple material, e. g. shrink films, container liners, food wrap films, packaging bags or greenhouse films. These films are processed by extrusion line -film blowing line, which has several parameters. Changing the parameters, different films are made with different geometric and mechanical properties. From this viewpoint, the processing parameters are essential to get perfect properties. While my research area is about polyolefins, it is worth to investigate the effect of some parameters on mechanical properties [1-3].

Another interesting phenomenon is the orientation [4-6]. During the film blowing process, the film is biaxially oriented. The oriented structure has better mechanical strength, as polymer chains are arranged in order. The strength depends on the stress direction. Also in biaxially oriented materials, one direction is more oriented than the other.

My aim is to process polyethylene films with different film blowing parameters, and to measure their yield stress and some geometric properties. During my work, the phenomenon of orientation is also investigated. The effect of the processing parameters on strength is examined. It is investigated, how the setting parameters influence geometric sizes, and how extruder and rolling speed influence orientation, which can be determined by the magnitude of yield stress.

* Corresponding author: Tel.: +36 30 9666276
E-mail address: nagy.dorottya@gamf.kefo.hu

2 Experimental

2.1 Method

In this study, a standard polymer (polyethylene) was processed by a Collin Teach-line extrusion line with an E20T single-screw extruder and a BL200 type blown film line [7]. The method arrangement can be seen in Figure 1.

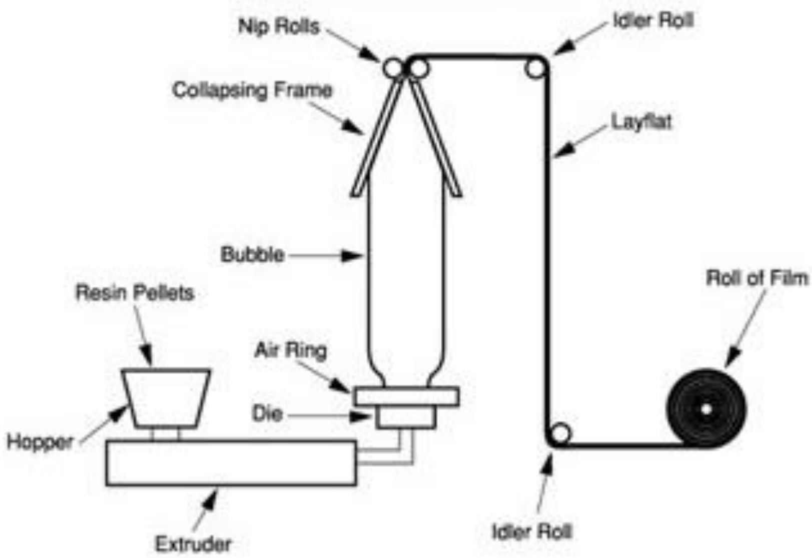

Figure 1.Film blowing line [8]

The temperature in the heat zones were 170-180-190°C respectively. The extruder machine was water-cooled around the hopper, and the blown film line was air-cooled. The extruder speed, the rolling speed and the film diameter were changed during the process. The extruder speed was 50, 60 and 70 1/min, the rolling speed was 10, 20 and 30 1/min, and the film diameter was 60, 90 and 120mm. When a value was changed the other two were constant at a reference value. The reference values are the following: 50 1/min extruder speed, 10 1/min rolling speed and 120mm film diameter.

After the process, the width and thickness values were measured and standard samples were cut from the blown film. The samples were parallel or perpendicular to the rolling direction, so that the orientation can be measured between the two directions. The samples were measured for tensile strength by an Instron 3366 universal testing machine [9]. The tensile stress at yield was taken as the failure threshold. For the most samples, elongation continued after this threshold, but the film was already torn.

2.2 Material

One type of low density polyethylene (LDPE), TIPOLEN FB 243-51 was used for the measurements [10]. It was purchased by MOL Group, manufactured by TVK Nyrt. in Hungary. This material is appropriate for film blowing and blow moulding. Its hygienic properties are quite good even for food contact and pharmaceutical and toy applications. This LDPE can be used in a conventional extrusion machine at 170-190°C. It has good thermal stability and does not contain any substances, so it is suitable for recycling.

3 Results and Discussion

During the film blowing process seven settings were made. In Table 1. there are the parameters set up, and the results from the different settings.

Table 1. Film blowing parameters and results

Number of measure-ment	*Parameters*			*Results*				
	$n_{ext.}$ (1/min)	*$n_{roll.}$ (1/min)*	*D_{film} (mm)*	*Actual film width (mm)*	*Thickness (mm)*	*Sample width (mm)*	*Tensile stress at yield (MPa)*	
							=	⊥
1.			60	120	0,058	6,5	8,81	7,82
2.	50	10	90	145	0,033	6,5	16,55	8,2
3.			120	180	0,039	6,5	7,99	4,92
4.	50	20	120	215	0,019	6,5	6,91	3,62
5.		30		200	0,015	6,5	9,36	8,71
6.	60	10	120	215	0,048	6,5	6,35	7,52
7.	70			220	0,028	6,5	14,37	10,52

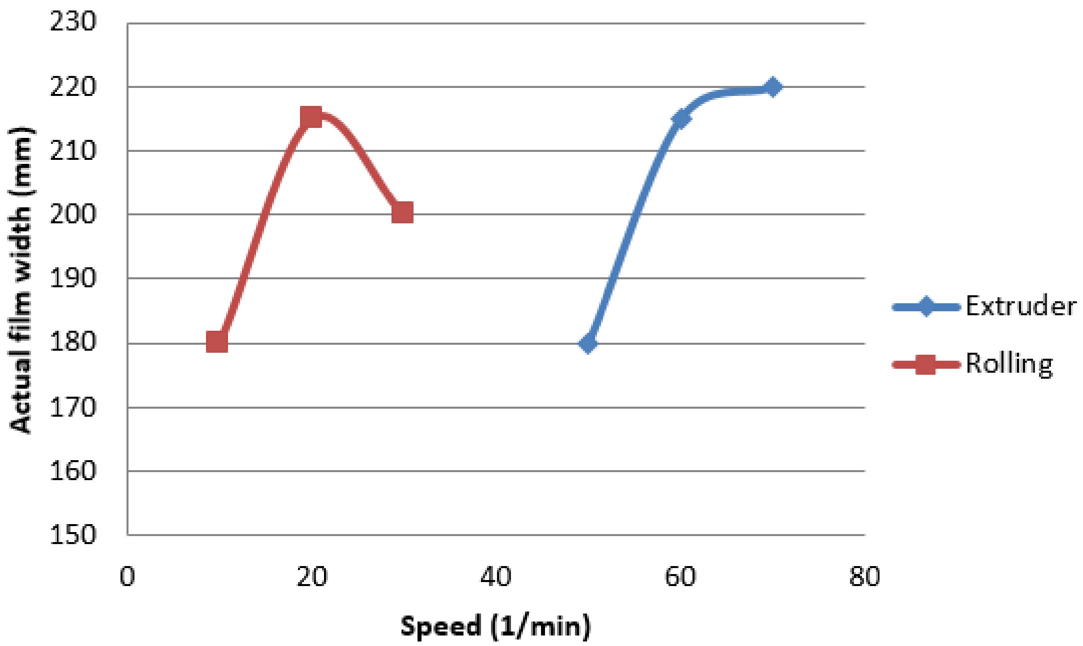

Figure 2. Film width in function of extruder and rolling speed

In Figure 2, actual film width can be seen in function of extruder and rolling speed. The film width definitely increases with the extruder speed, because much more material gets to the equipment. The film width-rolling speed curve seems to have a maximum value. If the rolling speed is too high, the polymer material runs out. On the other hand, if the rolling speed is too low, there is no enough material by the blown film.

The film thickness is shown in function of extruder and rolling speed (Fig. 3.). The film thickness decreases with the rolling speed, because the rolls are rolling out the film. The thickness-extruder speed curve has a maximum value. Theoretically, the thickness- extruder speed curve should increase, because of the quantity of the material. The first and second points show an increasing tendency. The last point can differ because of deviation. Every parameter setup was investigated on three samples, and mean values were calculated from three results, but in further measurements it is worth to investigate more.

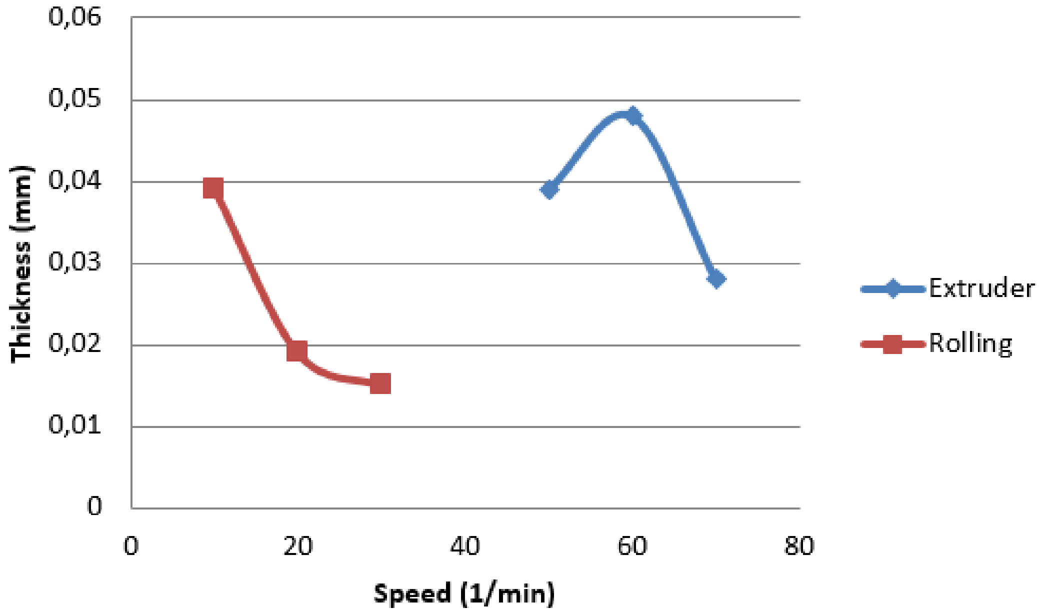

Figure 3. Thickness in function of extruder and rolling speed

In Figure 4. tensile stress at yield is shown, in function of extruder and rolling speed, according to the orientation. = means parallel, and _L means perpendicular direction to the rolling. Except for one value, this is always the parallel one, which has the highest yield strength. During the film blowing process, the molecules are drawn in higher extent to the parallel direction, than to the perpendicular. The molecules are located to an orderly shape, which means higher degree of crystallinity. That is why the mechanical strength is better for the oriented, crystalline polymers.

It was measured that for higher extruder or rolling speed, the stress value increases, but these curves has a minimum. The increasing tendency in both direction means that the films are biaxially oriented.

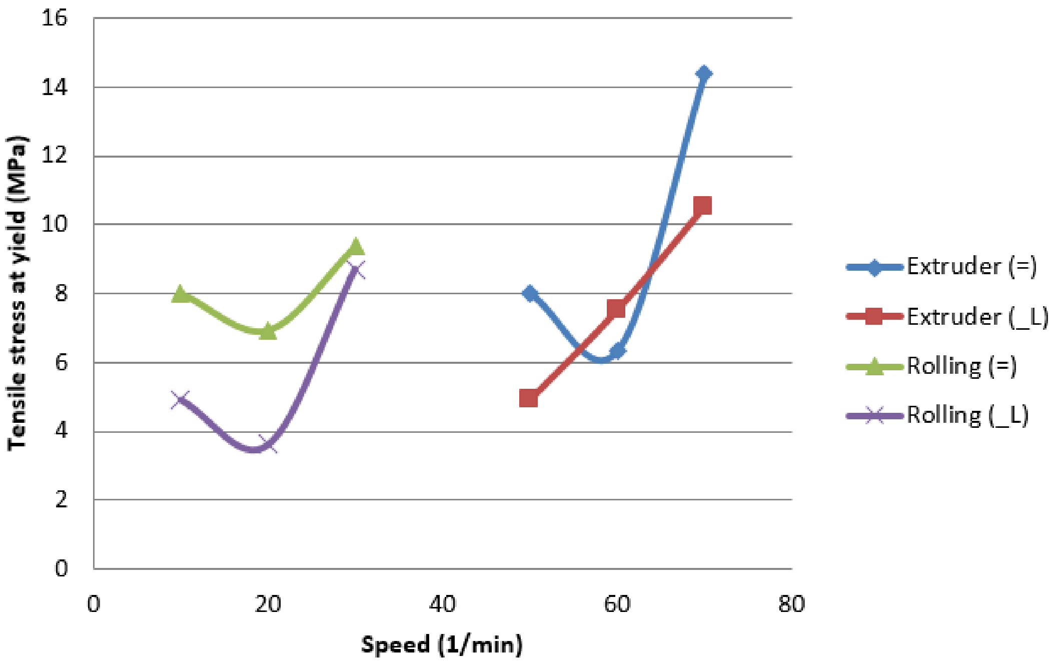

Figure 4. Yield stress in function of extruder and rolling speed, according to orientation (= parallel, _L perpendicular)

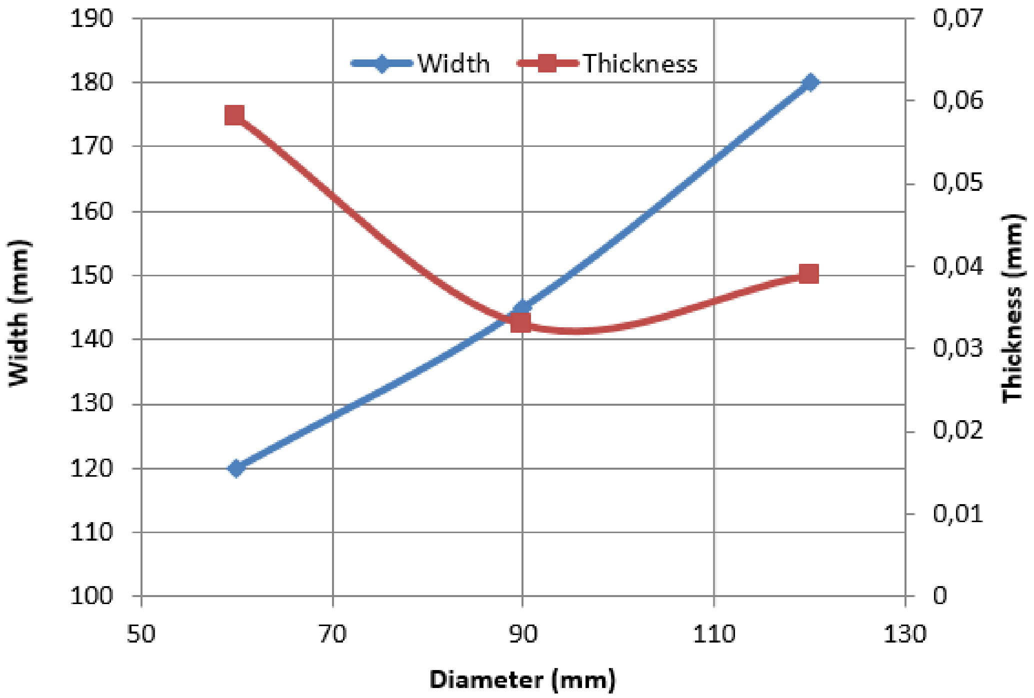

Figure 5. Film width and thickness in function of film diameter

Also the film diameter was changed (Fig. 5.). Because of this effect, the film thickness and width were different for the different values. When the diameter increases, the width shows linear rising tendency, while film thickness decreases. Theoretically, film diameter and width are the same, but diameter is measured during the blowing process, while width is measured after rolling.

In Figure 6, yield stress in function of film diameter can be seen, according to the orientation. = means parallel, and _L means perpendicular direction to the rolling. These curves show decreasing tendency, but they have a maximum, even the first and last values are near to themselves. Also in this case, the parallel samples have more strength, than the perpendicular ones. Also in this diagram, more material means more strength. If the diameter is bigger, the strength is lower, unless the material shortage is replaced.

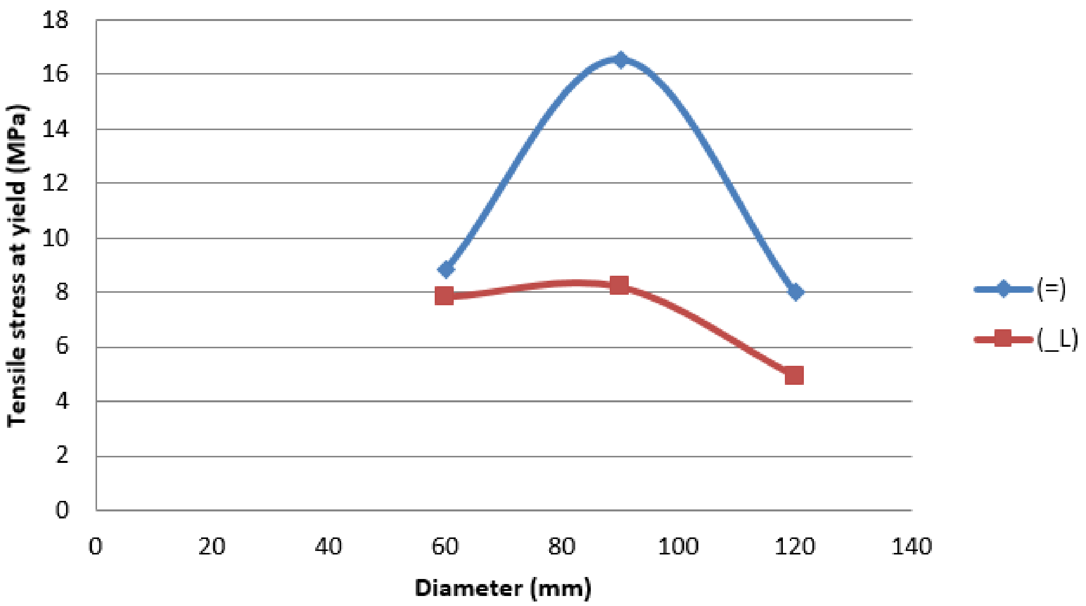

Figure 6. Yield stress in function of film diameter, according to orientation (= parallel, _L perpendicular)

4 Conclusions

During the measurement, polyethylene film was processed with different film blowing parameters. After the process, the geometric sizes were measured and samples were cut in two directions. These samples were examined for yield strength. The fact that extruder and rolling speed influence geometric sizes, was revealed. Generally, the extruder or rolling speed raises film width and reduces film thickness. Also processing diameter has a similar effect for these properties. Extruder or rolling speed increases, while diameter demolishes yield strength. However, these curves do not show linear behavior. The phenomenon of orientation was confirmed, while usually the parallel samples have the highest yield strength.

Acknowledgment

This research is supported by **EFOP-3.6.1-16-2016-00006 "The development and enhancement of the research potential at John von Neumann University"** project. The Project is supported by the Hungarian Government and co-financed by the European Social Fund.

References

[1] Structure and properties of oriented polyethylene films (2003) Srinivas, S et al.,POLYMER ENGINEERING AND SCIENCE, Volume: 43, Issue: 4, Pages: 831-849, DOI: 10.1002/pen.10069
[2] The influence of processing route on the structuring and properties of high-density polyethylene (HDPE)/clay nanocomposites (2012) Abu-Zurayk, Rund, Harkin-Jones, Eileen, POLYMER ENGINEERING AND SCIENCE, Volume: 52, Issue: 11, Pages: 2360-2368, DOI: 10.1002/pen.23189
[3] Oriented structure and anisotropy properties of polymer blown films: HDPE, LLDPE and LDPE (2004)Zhang, XM,et al., POLYMER, Volume: 45, Issue: 1, Pages: 217-229, DOI: 10.1016/j.polymer.2003.10.057
[4] Effect of processing on the crystalline orientation, morphology, and mechanical properties of polypropylene cast films and microporous membrane formation (2009), Tabatabaei, Seyed H et al., POLYMER, Volume: 50, Issue: 17, Pages: 4228-4240 , DOI: 10.1016/j.polymer.2009.06.071
[5] Physical properties of polyethylene/silicate nanocomposite blown films (2003), Wang, KH et al., JOURNAL OF APPLIED POLYMER SCIENCE, Volume: 89, Issue: 8, Pages: 2131-2136, DOI: 10.1002/app.12358
[6] Changes in the molecular orientation and tensile properties of uniaxially drawn cellulose films (2006) Gindl, Wolfgang et al., BIOMACROMOLECULES, Volume: 7, Issue: 11, Pages: 3146-3150, DOI: 10.1021/bm060698u
[7] https://www.drcollin.de/en/product-units/teach-line/#c809
[8] http://www.industrialextrusionmachinery.com/plastic_extrusion_blown_film_extrusion.html
[9] http://www.instron.co.hu/hu-hu/products/testing-systems/universal-testing-systems/electromechanical/3300/3360-dual-column
[10] http://plastimpex.cz/TDS/LDPE/Tipolen/FB%20243-51_EN.pdf