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The Experimental Research of Nylon 6 Blends with Low-Density Polyethylene (PA6/LDPE) blends and Its Cast film

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Abstract. The effect of screw configurations in melt conveying section on PA6/LDPE blends and casting film was studied and the arrangement form and types of distributive mixing and dispersive mixing elements were considered. Compared with the screw configurations for concentrated arrangement, the blends prepared by screw configurations for staggered arrangement had better property through experiment study, and the results were consistent with the theory analysis. The blends and casting film prepared by the screw configuration of SPE+KB had best property. The mechanical properties of PA6/LDPE blends agreed well with that of casting film. The screw configurations for staggered arrangement which had uniform shear and backflow capacity were more suitable for preparing film with excellent property.

Keywords: blending procedure, screw configurations, casting film.
PACS:83.80.Tc

INTRODUCTION

Co-rotating twin-screw extruders are widely used in polymer blending modification, filling modification and reactive extrusion for their excellent mixing performance. To achieve these functions, a key issue is to design and combine the screw configuration with good mixing ability and other specific capabilities. Xu Weiwei studied the effect of screw configuration of co-rotating twin-screw extruder on the PP/PA6 blend, and compared the impact resistance and processing flow properties of the blends. During the blending process, when the melting section is a shear element (KB) and the melt conveying section is a six polygon elements (SPE), this screw configuration improves the toughness and processing flow properties of the PP/PA6 blend [1]. Liang Wenhu [2] analyzed the effect of screw configuration on mechanical properties of PPO/PA66 alloy. Zhou Xinhui et al. [3] studied the effect of staggered angle of kneading block in the melting section of co-rotating twin screw on the morphology structure of the incompatible system. Liu Qingfeng et al. [4] also analyzed the mixing ability of different screw configurations. Japanese Yasuya Nakayama et al. [5] studied the melt mixing effect of a new type of inclined kneading disk in a co-rotating twin-screw extruder. This new type of element effectively controls the balance between the pressure building and the mixing quality. Barrera et al. [6] established a three-dimensional model of co-rotating twin-screw extruder and analyzed the velocity and pressure distributions by using the finite element method. Zhang Xianming and Sandrine Hoppe studied the residence time, screw speed and volume distribution of twin-screw extruders [7].

Previous studies on screw configuration mostly focus on the simple configuration or the mixing capacity of different screw elements. However, there are few studies on the configuration of complex screw configurations. The influence of arrangement method for distribution mixing elements and dispersive mixing elements on the blend performance will be studied in this paper.

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SIMULATION ANALYSIS

Mathematic model

According to the actual process conditions and the characteristics of the blend system, assumptions are as follows:

a) Without considering the effects of gravity and inertial forces on the flow field.
b) The flow fluid is incompressible and completely full in the area.
c) The flow process is isothermal and stable.
d) The flow of the melt in the simulation zone is laminar flow.
e) Non-slip conditions between the melt and the barrel in the simulation zone.
f) The melt exhibits non-Newtonian characteristics, select the Bird-carreau model and the constitutive equation(Eq.1):

$$\eta = \eta_0 (1 + \lambda^2 \cdot \dot{\gamma}^2)^{\frac{n-1}{2}} \quad (1)$$

where η is non-Newtonian viscosity, Pa·s, η_0 is Zero-shear viscosity, Pa·s, λ is relaxation time, s, $\dot{\gamma}$ is shear rate, 1/s.

Screw configuration

The configuration of the specific exchangeable zone shown in Table (1). The TME is turbine mixing element and the SME is a grooved screw element. Both two elements all have good distributive ability. The KB element has strong shearing capacity. 1# and 2# are concentrated arrangement of distributive and dispersive mixing elements. 3# and 4# are staggered arrangement of distributive and dispersive mixing elements. Compared 1# and 3#, 2# and 4# can study the effect of concentrated or staggered arrangement of distributive and dispersive mixing elements on the mixing ability of the blend.

Table (1). Screw configurations

Number	Screw configuration	Type
1#	TME/60+KB/60/60°	Concentrated arrangement
2#	SME/60+KB/60/60°	
3#	TME/30+KB/30/60°+TME/30+KB/30/60°	Staggered arrangement
4#	SME/40+KB/30/60°+SME/20+KB/30/60°	

Boundary conditions

During the processing, the melt enters the flow channel from the inlet at a certain volumetric flow rate. After the mixing of the screw, the melt flow out from the outlet. In this process, five boundary conditions are set, and the specific boundary conditions shown in Table (2).

Table (2). Boundary conditions of flow field

Boundary	Boundary conditions	Parameter
Inlet	Volume flow rate	Qv=2.294×10-6m3/s
Outlet	Outlet pressure	P=5MPa
Left screw	Angular velocity	N_{s1}=4.187rad/s
Right screw	Angular velocity	N_{s2}=4.187rad/s
Barrel wall	Non-slip conditions	V_n=0 V_s=0

EXPERIMENTAL SECTION

Materials

The materials used in the experiment shown in Table (3).

Table (3). Experimental materials

Material name	Grade	Manufactor
PA6	1013B	UBE, Japan
LDPE	LD100AC	Yanshan petrochemical company
PE-g-MAH	TRD-100H	Wujiang Srida Plastic Industry Co., Ltd.

Experimental equipment

The equipment used in the experiment shown in Table (4).

Table (4). Experimental equipment

Device name	**Model**	**Company**
Co-rotating twin-screw extruder	LSM30/34	Leistritz, German
Injection molding machine	HTF120X2	Haitian Plastics Machinery Group Co., Ltd
Film casting machine unit	RM-200C	Harbin Harpro Electrical Technology Co.LTD.

INFLUENCE OF SCREW CONFIGURATIONS ON PA6/LDPE BLENDS

Sample Preparation

In this experiment, the screw zone is set up to 120mm. The screw configuration is shown in Figure 1. The exchangeable screw configuration is the same as that of used in the simulation analysis, as shown in Table (1).

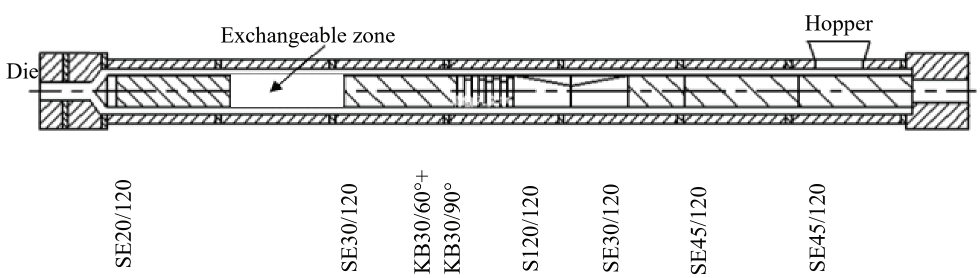

Figure 1. The barrel and screw configurations

PA6 was dried for 24 hours in a vacuum drying box at 80℃. LDPE, PE-g-MAH and dried PA6 with a ratio of 22:6:72 are added to the high-speed mixer and mixed at a low speed for 5 minutes, then at a high speed for 5 minutes. The pre-mixed materials were granulated in co-rotating twin-screw extruder. The prepared particles are added into the injection machine. Standard sample for testing were molded in injection machine.

Performance Testing

Analyze and measure the size of the LDPE dispersed phase of blend using SEM images, and then calculate the average particle diameter of the dispersed phase.

The tensile strength according to GB/T 1040.1 - 2006 standard, and the tensile rate is 50mm/min. The bending strength according to GB/T 9341 - 2008 standard, and the experimental speed is 10mm/min. The notched impact strength according to GB/T 1043.1 - 2008 standard. In order to analyze the comprehension mechanical properties of blend,

$$C_s = \frac{I_s}{1MPa} \times A + \frac{T_s}{1MPa} \times B + \frac{B_s}{1kJ \cdot m^{-2}} \times C \tag{2}$$

where C_s, I_s, T_s, and B_s are comprehension mechanical properties, notched impact strength, tensile strength, and bending strength respectively, A, B, and C are weight index of I_s, T_s, and B_s respectively.

PA6/LDPE CASTING FILM EXPERIMENTS

Sample Preparation

The previous granulation of PA6/LDPE was casted to film by the film casting machine, and film samples for testing were prepared.

Performance testing

The thickness of casting film is determined according to GB/T6672-2001 standard, and the width of casting film is determined according to GB/T6673-2001 standard.

Using American Instron1185 universal material testing machine to measure the tensile properties of PA6/LDPE film. The tensile rate is 50mm/min. The tearing performance of film is determined according to the GB/T 16578.1-2008 standard and the experimental speed is 200mm/min.

RESULT ANG DISCUSSION

In order to indicate the relationship between screw configurations and the properties of the casting film, the simulation results, the dispersed phase size and distribution, the mechanical properties of blend, and the mechanical properties of casting film were as shown in Table (5). As shown in Table (5), the stronger the backflow(distribution mixing) capacity of the screw is, the less the dispersed phase size is, the more uniform the size distribution of the dispersed phase is, the better the mechanical properties of blend and casting film are. When combining the same kinds of screw components, using staggered arrangement of distributive and dispersive mixing elements to improve the performance of the film.

Table (5). Relation among screw configurations and property of blends and casting film

	Shear capacity	Back-flow rate	D	PDI	Mechanical properties of blends	Mechanical properties of films	
						Tensile strength	Tearing strength
1#	12359	0.366	0.417	1.063	163.363	36.801	17.62
2#	14813	0.394	0.391	1.052	168.323	44.899	27.33
3#	13986	0.509	0.379	1.044	163.415	44.113	26.67
4#	14924	0.652	0.373	1.045	170.2	48.467	29.23

Note: The configuration shear capacity is measured using the weighted average shear stress (Pa), the backflow capacity is measured by the backflow rate($10^{-6}m^3/s$), and the dispersed phase size and distribution are measured by volume average particle size (μm) and PDI (Particle size Distribution Index), the mechanical properties of the blended system were measured by the comprehensive mechanical property index. The mechanical properties of the film were measured by tensile strength (MPa) and tearing strength (kN/m).

CONCLUSION

The screw configuration with a certain uniform shearing capacity and backflow capacity and the distributed mixing elements and the dispersed mixing elements arranged in a staggered manner is more conductive to the improvement of the film performance.

REFERENCES

1. Xu Weiwei, Influence of screw configurations of tse on the properties and morphology of PP/PA6 blends [D]. Beijing University of Chemical Technology, 2009.
2. Liang Wenhu, Influence of screw configurations on PPO/PA66 alloy [D]. Beijing University of Chemical Technology, 2012.
3. Zhou Xinhui, Ma Xiuqing, Cao Bin. Influence of Staggering Angle of Kneading Block of Co-rotating Extruder on Phase Morphology of Immiscible Polymer Blend [J]. China Plastics Industry, 2006,34(7):26-18.
4. Liu Qingfeng, Ma Xiuqing. A Mixing Performance Analysis on the Different Screw Configuration In the Process of Twin Screw Co-directional extrusion [J]. China Rubber/Plastics Technology and Equipment, 2006,32:1-5
5. Yasuya Nakayama, Eiji Takeda, et al. Melt-Mixing By Novel Pitched –Tip Kneading Disks In A Co-Rotating Twin-Screw Extruder [J]. Chemical Engineering Science, 2011:103-110.
6. M A Barrera, J F Vega, et al. Three-Dimensional Modelling of Flow Curves In Co-Rotating Twin-Screw Extruder Elements [J]. Journal of Materials Processing Technology, 2008:221-224.
7. Xian-Ming Zhang, Sandring Hoppe, et al. Local Residence Time, Residence Revolution, and Residence Volume Distributions in Twin-Screw Extruders [J]. Polymer Engineering and Science, 2008:19-28