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PROBLEMS OF SPECIFIED QUALITY POLYMER MIXTURE PREPARATION WHEN UTILIZING WASTE IN COEXTRUSION EQUIPMENT

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Summary. New construction of coextrusion equipment for mixing initial plastics with polypropylene (PP) recyclates with HDPE and LDPE with HDPE is offered. The additions influence on the mixture of PP/ HDPE block-copolymer propylene is studied. The problem of polymers compatibility for the process of second polymer materials coextrusion is investigated.

Key words: multilayer polymer material, coextrusion, adhesion, layers bounding strength, material stress-strain properties, polymer mixture receipt.

INTRODUCTION

Today the best way of getting polymer package and packing with specified regulated complex of properties is to construct multilayer polymer materials (MPM). That is why the task of processes in-depth studying MPM getting technology developing has become of vital importance.

An important direction of multilayer principle using is utilization of articles made of polymers. In this case an inner layer in a multilayer system is formed of the waste of polymer materials. That is how the ecological problem of waste is solved.

The variety of MPM, wide range of their components determines the necessity to search for efficient technological methods of their getting. Some of these processes are universal, some are specific, that is they can be applied only in definite layers combinations. Some of them demand special equipment to be constructed and complicated methods of conjunct surfaces preparation.

Applying MPM is an attempt to achieve the most optimal for these purposes level of the following properties: breaking strength, strain lengthening, puncture, tearing strength, water steam, water, aromatic substances, oils and fats impermeability, ultraviolet radiation, thermal properties (working temperatures range), high temperatures shrinkage, processing (good weldability), possibility to put the seal on it,

thermal forming, ability to be processed on different packing automates [Kagan D.F. 1989].

Coextrusion is a a new step in producing MPM with utilization of second polymer materials. This method has a significant advantage compared to other methods of getting multilayer materials (extrusion covering and laminating, laminating with the help of either wet or dry binding agent, etc.). The method is based on combined extrusion of two or more polymers through one forming extrusion head.

Only coextrusion allows to get MPM in the form of a hose (when the melts are coextruded through one forming slot) and by bulging to form a package of different capacity and shape. Packages made of coextruded plastics play the key-role in making the process of metal and glass packages replacing with plastic ones in food industry faster.

The advantages of this method are in the following. It makes possible to get multilayer materials within one stage with optimal spending of power and materials; excludes the application of glues and dissolvents, hot melts and other components for conjuncting separate layers; gives an opportunity to get MPM when conjuncting very thin layers. It allows to reduce the degree of heat-sensitive polymers destruction because they can be used as the middle layer; promotes the process productivity owing to the application of two or more extruders in combination with one head.

Such an approach allows to exclude many technological operations necessary to get MPM. Besides, it is the only method of producing MPM when MPM can be made of second polymers without half-finished products. That is why the cost of MPM made by coextrusion is in average 20% lower than the cost of similar multilayer films produced in other ways [Elliev D. 1991].

RESEARCH OBJECT

The properties of any MPM should be not just good but such ones that are necessary for particular applying conditions. So, using MPM for packing not only guarantees that the quality will be preserved and the products will not be spoiled but promotes considerable perfection of technological process of unpacking and packing, provides more rational storage and transportation of products, reduces natural diminishing of products, shortens the outlay of packing material as well.

Complex of valuable usage and technological properties of MPM consisting of the layers of different chemical nature and structure and possessing different properties can be realized in the process of material usage only on condition that MPM behaves as a single entity. It is achieved through appropriate degree of binding strength between the layers of the system. The problem of layers conjunction strength in a multilayer material and the ways of its increasing is the determining one both in making the theory of MPM constructing and when optimizing technological processes of their producing.

It is known [Berdyshev S.M. 1991] that the level of interaction between the layers of MPM significantly influences the transportation of substance through the package leading to the reduce of material permeability. Interlayer (adhesion) connections increase the strength of MPM on the whole. When warping the material dangerous can be both defects that existed earlier in the material and those appearing in

the process of warping in the most strained parts. In case of multilayer (for example, three-layer) system the danger of overstraining appearing is considerably smaller than in case of one-layer material not only owing to 'curing' defects but owing to the processes of strains redistribution when warping either ('blocking effect').

It has been found out [Narisava K. 1987] that the 'blocking effect' reflects the possibility of transferring the power of growing defect to the conjunct layer. It reduces the danger of overstrains appearing that lead to destruction. It increases the deformation capacity and strength of multilayer materials.

So, an important property of layers conjunction strength [Bledzky A. 1994] lies in the ability to redistribute the tense between the layers and 'synchronize' their work in common warping. Currently, there exist only qualitative criteria of selecting polymers for coextrusion. Such criteria possess the following disadvantages:

-recommendations from different sources hardly adjust with each other;

-possess inner contradictions;

-do not allow to forecast quantitatively the level of layers conjunction of heterogeneous polymers;

-do not take into consideration the regulated technological parameters of MPM getting process.

The aim of work is to increase the conjunction strength of the layers made of polymer materials waste in a multilayer polymer product by means of rationalizing the mixture composition consisting of heterogeneous second filled polymers to get a ready-made article of good quality.

RESULTS OF EXPERIMENTAL RESEARCH

In Ukraine from 1993 up to 2009 the usage of plastics has increased from 128 thousand tons to 489 thousand tons. It has led to the increasing of waste amount. In the country there is being solved the question of their displacing as their burning is connected with the emission of dangerous gases. Biologically destructed plastics are very expensive. That is why for recycling with the help of extrusion we have studied the possibility of mixing the initial plastics with polypropylene recyclates (PP) with HDPE and LDPE with HDPE. Polymers with different proportion have been mixed in the extruder and granulated. PPs with the density 0.903 g/cm3 have been used, LDPE with density 0.925 g/cm3. Mechanical properties of different mixtures are shown in the table 1.

As we can see from the table 1, when mixing PP with HDPE tearing lengthening is reduced because of bad adhesion of phases, their incompatibility. Within proportion PP/HDPE 90:10 and 70:30 more fine-grained structure and improved morphology are observed. When increasing the proportion of HDPE in PP crystallinity is reduced to 38% (HDPE and PP have crystallinity of 73 and 72%, correspondingly).

The influence of additives in the mixture PP/HDPE propylene block-copolymer with 6% of ethylene (P/E) in amount of 5-20% has also been studied. The properties of mixtures are shown in the table 2. As it is seen from the table 2, 5% additive of P/E copolymer significantly increases tearing lengthening and impact resistance. The increased proportion of the copolymer increases only the elasticity module and the material becomes more tough.

Table 1**. PP and HDPE Mixtures Properties**

HDPE,%	Jung's module, kg/mm^2	Straining density, kg/mm^2	Tearing lengthening, %	Impact resistance, J/m
0	63.6	3.6	12.6	7.0
5	68.4	3.6	10.1	9.3
10	72.6	3.4	8.6	8.5
20	72.0	3.1	7.1	6.5
30	71.0	3.2	6.9	9.3
40	64.7	3.1	8.3	7.5
50	69.2	2.9	7.1	7.0
100	55.2	1.6	560.0	38.3

Table 2**. PP/HDPE Mixture Mechanical Properties -70:30 with Copolymer (P/E)**

Copolymer, % P/E	Jung's module, kg/mm^2	Straining density, kg/mm^2	Tearing lengthening, %	Impact resistance, J/m
0	68.9	3.2	6.8	9.3
5	11.4	1.7	15.9	16.8
7	79.6	1.7	2.8	10.2
10	78.4	2.7	6.1	10.2
12	80.9	2.8	5.7	10.6
15	83.6	3.7	7.0	13.0
20	76.3	2.9	6.3	12.1

As in our country 50% of all plastics are LDPE and HDPE that is why in the investigations there has been examined the possibility of mixing initial (fresh) LDPE with recycled HDPE. The mixtures properties are shown in the table 3.

Table 3**. Mixtures Properties**

HDPE, %	Jung's module, kg/mm^2	Straining density, kg/mm^2	Tearing lengthening, %	Impact resistance, J/m
0	15.0	0.9	83.0	More than 200
10	20.9	0.9	251.6	117
20	26.0	1.0	325.1	62
30	35.2	1.1	487.4	23
40	41.1	1.1	514.6	23
50	35.4	0.5	9.0	22
100	54.8	1.6	560.0	38

As it is seen from the table 3 when the proportion of HDPE in LDPE is increased the module of elasticity is increased, when HDPE is 40% the lengthening is six times higher, impact resistance becomes lower. Up to 50% of HDPE-recyclate can be put into

LDPE. When the amount of HDPE is 50% it is considered that it undergoes destruction on molecules with less strong connection.

A serious problem for the process of polymer materials coextrusion is their compatibility. Usually to waste collecting factories they are brought as polymer mixtures that are incompatible with each other and exfoliate when being processed. Meanwhile, waste sorting is a very complex and expensive process. To solve the problem of combining the incompatible polymers there are produced combination agents, the so-called compatibilizators. Such functional polymers should be used when possible if it is economically beneficial. Small additions in amount of 2-4% allow to get high-resistant and high-filled polymers.

Thus, if the problem of polymer materials waste mixture preparing for coextrusion is solved correctly, we can get mixtures with other plastics, for example, PE from disposable tableware and other things that have not lost most of their properties. It is possible to make jerrycans for petrol, oils, chemicals, litter bins and baskets and many other things. Besides, films with a bit lower quality can also be made if there is no need in high quality films (they can be used in agriculture, water bodies bottoms, bags for collecting waste outdoors, etc.).

On the basis of conducted investigations the most rational multilayer structure consisting of one layer of polymer materials waste mixture, two layers of adhesives and two layers of initial polymer has been defined. In its turn, the polymers waste mixture consists of initial polymer, filled household polyethylene, polypropylene, polystyrene waste and the filler. The samples of 0.33, 0.5, 1 liter tankages on the basis of second polyethylene of high and low density, polypropylene have been got. In the produced tankages there has been made the sterilization of juices in the autoclaves of Slavyanoserbsk canning factory. The obtained practical results allow to forecast quantitatively the level of heterogeneous polymers mixture layers conjunction and to take into consideration the regulated technological parameters of MPM getting process.

CONCLUSION

It has been established, that polymer materials waste layers conjunction strength increasing in a multilayer polymer product for getting a high-quality ready-made product is possible through defining the proper percentage composition of the mixture consisting of heterogeneous second filled polymers as well as adding a filler to the mixture.

The analysis of second polymer materials compatibility for forecasting the level of polymers interlayer interaction and, correspondingly, valuating polymer products usage characteristics has been made. For this purpose the technological process of getting multilayer polymer package with high level of layers interaction in the system has been elaborated. Such package possesses improved usage characteristics (increased deformations, temperature fluctuations resistance and lower steam and gas permeability).

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ПРОБЛЕМЫ ПОДГОТОВКИ ПОЛИМЕРНОЙ СМЕСИ ЗАДАННОГО КАЧЕСТВА ПРИ УТИЛИЗАЦИИ ОТХОДОВ В СОЭКСТРУЗИОННОМ ОБОРУДОВАНИИ

Дядичев В.В., Терещенко Т.М., Дядичев А.В.

Аннотация. Предложена новая конструкция соэкструзионного оборудования для смешения исходных пластиков с рециклатами полипропилена (ПП) с ПЭВП и ПЭНП с ПЭВП. Изучено влияние добавок в смесь ПП/ПЭВП блок-сополимера пропилена. Исследована проблема совместимости полимеров для процесса соэкструзии вторичных полимерных материалов.

Ключевые слова: многослойный полимерный материал, соэкструзия, адгезия, прочность соединения слоев, механические свойства материала, рецептура полимерной смеси.