TAPPI Press

11th TAPPI European Place Conference 2007

May 14-16, 2007
Athens, Greece

Volume 3 of 3

TAPPI Press

11^{th} TAPPI European Place Conference 2007

May 14-16, 2007
Athens, Greece

Volume 3 of 3

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571
www.proceedings.com

ISBN: 978-1-60560-509-8

Some format issues inherent in the e-media version may also appear in this print version.

TAPPI Press
15 Technology Parkway South
Norcross, GA 30092

About this conference

The 11th TAPPI European PLACE Conference - (Polymers, Lamination, Adhesives, Coating & Extrusions) hosted at the Westin Athens Astir Palace Beach Resort in Athens, Greece- May 2007.

Attendees experienced the beauty and culture of Greece while enjoying the premier technical event for the European Flexible Packaging and Converting Industry. The conference program has a special emphasis on the latest trends, applications and technologies affecting the film extrusion, extrusion coating and end use applications including:

- New developments in polymers: raw material, the processing and converting
- What is new in machinery, extrusion and process controls
- Final products, environmental aspects and packaging
- Characterization of raw materials

TAPPI Press

11th TAPPI European Place Conference
2007

TABLE OF CONTENTS

Volume 1

Volume 2

Volume 3

AUTHOR INDEX

PET extrusion coating - taking extrusion coating to a new level

Mikko Peltovuori
Stora Enso
Karhula, Finland

ABSTRACT

Extrusion coating with PE-LD is highly competed area. To make profit it is necessary to head for new areas of extrusion coating. Coating with PET is a good option. This paper will examine the major differences between PE-LD and PET coating. At first we will look through differences in polymers and then machinery and processing. Also applications where PET coated products are used will be presented.

INTRODUCTION

As the competition is getting fiercer in PE coating it is good to head for new areas in the search for more profitable extrusion coating. As well as PE coated paperboard products, PET coating offers environmentally sound option to full plastic or even aluminum materials.

Getting into PET coating might need big scale investments and let me tell you, it is not easy but it gives you a nice challenging work where you might be able to make reasonable profits.

POLYMER COMPARISON BETWEEN PE VS. PET

PET is an acronym from polyethylene terephthalate. PET belongs to polymer group called polyesters. Polyesters are thermoplastic polymers which have ester functional in their main chain. PET is produced in esterification reaction. Esterification reaction results water as by-product. Esterification is also reversible reaction which means that if there is water present when PET is melted the process is reversed and PET will degrade into monomers. Polyesters are normally hard, tough high temperature polymers. To understand the difference between PE and PET in extrusion coating let's have a review of their chemical and physical properties.

Oxygen in the PET polymer chain gives some polarity to PET. This polarity can be seen as a natural surface tension of 42. PE-LD is non-polar and therefore surface tension is about 32. Although PET has some polarity it does not oxidize in the air gap in the same way as PE-LD. This makes challenging to get good adhesion between PET and the substrate. PET coating grades have also much narrower molecular weight distribution than PE-LD coating grades.

PET and PE-LD have some physical differences. PET has a melting point of about 245-250 C which is much higher compared to PE-LD's 110 C. PET in granulate form is highly crystallized which makes it very hard. LDPE granulate is rather soft.

EQUIPMENT

One of the most essential things for successful PET coating is to have processing equipment tailor made for PET coating. Since the characteristics of the PE and PET polymers are completely different the needed equipment also differs a lot. For this reason to begin PET coating on a sole PE line requires investments. After the line has been modified for PET the PE-LD coating starts to be challenging again.

Drying

Before you can even imagine running PET the line has to have polymer dryers. As PET esterification reaction is reversed by present water when polymer is melted, PET granulate must be almost completely free from bonded water before successful processing. PET granulates have moisture content of about 5 000 ppm before drying. Moisture content of lower than 50 ppm should be reached before processing. The polymer has to be dehumidified with the 140 degrees very dry (dew point around -30 degrees) air for six to eight hours before processing. There are lots of dehumidifier suppliers in the world but to find a supplier who can meet extrusion coating lines polymer consumption rate might be also a task itself. The design of the dryer is also very important. Bonded water in the PET granulates causes degradation in processing which results changing melt flow properties. To overcome this problem the dryer has to be designed so that every granulate get the same drying treatment. In other words, every PET granulate has to have the same amount of residual water. Same drying treatment means that air and granulate flow must be exactly the same everywhere in the dryer.

Drying also creates new demands for feeding equipment from the dryer to the extruders. Granulate cannot be exposed to the ambient air for long time because it will immediately start to absorb moisture. Therefore only dried air should be used in granulate conveying.

When the granulate leaves the drying hopper it's temperature is 140 degrees. Therefore the conveying pipes should stand that temperature. This will be a problem with flexible pipes and finding suitable and affordable material is a problem itself.

Hopper design is also important to avoid granulate to absorb moisture. Either the hopper should be so small that there is no time for granulate to absorb any moisture or it should be sealed from the ambient air.

Motors and extruders

Physical differences between PET and PE create completely different demands for motor design. PET is very hard in granulate form and its melting point is much higher than PE's. Toughness of the granulate requires much more torque from the motor. Also higher melting point means that granulate stays in solid state for longer time. These two things mean that motor loads will be for sure a problem if only motors designed for PE coating are used. For example in our factory if the same rpm's are used for PET and PE in same extruders, the motor load with PE is 20 to percent from max and with PET 85-95 percent from max.

Much more friction heat is also created when processing PET. With normal PE screw design the amount of friction heat will get too high in the first zones of the extruder. You might be able to run PET but your extruder maximum PET throughput might be so low that you can forget the profits. The PET extruder screw should produce low friction heat so you can control your temperatures. It should also convey the polymer gently and quickly after it has been melted. Too much shear or heat will degrade the polymer and then you are in trouble. With this type of screw, normal PE coating is not that easy anymore. A good option is to have something in between but will you then have problems with both? In the end, you must have multiple extruders to meet all the requirements.

Laminator and nip

Because PET does not oxidize in the air gap in the way that PE does, major portion of the adhesion to the substrate is made by mechanical adhesion. This fact makes some special requirements for the laminator and nip design.

The basic idea behind good adhesion is to apply high nip pressure in the nip before PET is completely solidified. This way you push the PET between paperboard's fibers and achieve good adhesion with mechanical locking. In other words the air gap should be as small as possible to avoid PET's temperature to decrease close to solidifying temperature. The laminator should be designed so that it is possible to get die as close to nip as possible. High nip pressure is also needed. In the PET coating you will not have problems with chill roll release.

PROCESSING

The key to successful PET processing is to handle temperatures and the neck-in. These two are the most difficult to handle but once you control them you are almost a winner.

Temperatures

Properties of PET make temperature setting and controlling very important. High melting point, hard granulate, adhesion, heat and shear sensitiveness create a very narrow temperature processing window. Too high temperature will very fast start to degrade the polymer and because of friction heat in high rpm's you are always very close to that limit.

You have to also remember that the temperature of the granulate entering the screw is somewhere between 100 and 140 degrees instead of room temperature in case of polyethylene. The temperature increase in the screw from granulate to melt is less than 200 degrees with PET and 300 degrees with PE.

Correct temperature settings for good PET processing can not be given in this paper because they are extremely dependant on the used resin and equipment. Only common guideline is to use higher feed section temperatures compared to PE processing. High temperature in the feed section will also decrease the amount of needed motor load.

Adhesion

Basic idea of achieving good adhesion to paper or paperboard substrate was described in the laminator nip design section. Adhesion has to be achieved with PET's mechanical locking within fiber matrix. Depending on the substrate a good adhesion can be achieved with normal flame pre treatment, good nip design, minimum air gap and good melt temperature control. With this normal processing there is a minimum coating weight to achieve good adhesion. If you need to go below this limit other methods should be used. For instance using primers, additives and co-extrusion will help you to go lower coating weights but it also means either more investments or more demanding processing.

Neck-in

PET has a nature of having a big neck-in and that will be one of the major difficulties in PET extrusion coating. PET has also a tendency for edge waving. Minimum air gap will keep the unsupported area short and it will decrease neck-in. Also some special equipment is needed to control neck-in. At least air pins and edge encapsulation can be used to control neck-in. Co-extrusion also offers solution for neck-in problem. You can use other polymers as a supporting layer for PET. This might not be possible in applications where PET is used for its' temperature resistance because also the supporting polymer has to stand the same temperature.

Other

In many cases color masterbatches are used when extrusion coating with PET. This makes coating much more challenging. This requires lot of research before success. There are a lot of masterbatch suppliers in the scene but to find masterbatch which can meet requirements of extrusion coating is difficult. The biggest step is to find masterbatch which have good covering abilities in such a low film thicknesses and has good dispersion. Masterbatch also interfere the processing properties of your natural PET resin. Masterbatch carrier resin should be the same as used in normal PET coating to minimize foreign material. Masterbatches have also additives which might cause processing problems under high temperature and shear rate of PET coating.

APPLICATIONS

PET's properties offer a wide selection of applications for PET coated papers and paperboards. Polyesters ability to stand high temperature has generated a big business for PET coated boards in ready made meal trays. PET coated paperboard tray has a good image of environmental product and it has replaced aluminum in many cases.

PET after coating is very amorphous which makes it very tough. This property of PET coated board has been utilized in packages where high strength is required. For example folded box small hand resistant medical packages have been created.

PET has also some polarity naturally which makes it a very good printing surface.

CONCLUSIONS

As you have noticed polyesters differs a lot from polyethylene's in chemical and physical properties and as well in extrusion coating. At first it might take some money to get right equipment and start will be challenging but after some practice you will find a new world of extrusion coating.

PET extrusion coating - taking extrusion coating to a new level

Mr. Mikko Peltovuori
10, 7630

2007
European PLACE Conference
14-16 May 2007 | Athens, Greece

PET Extrusion coating

- Polymer comparison PE vs. PET
- Equipment
- Processing
- Applications

Polymer comparison
PE vs. PET

TAPPI people resources solutions

PLACE

ICE

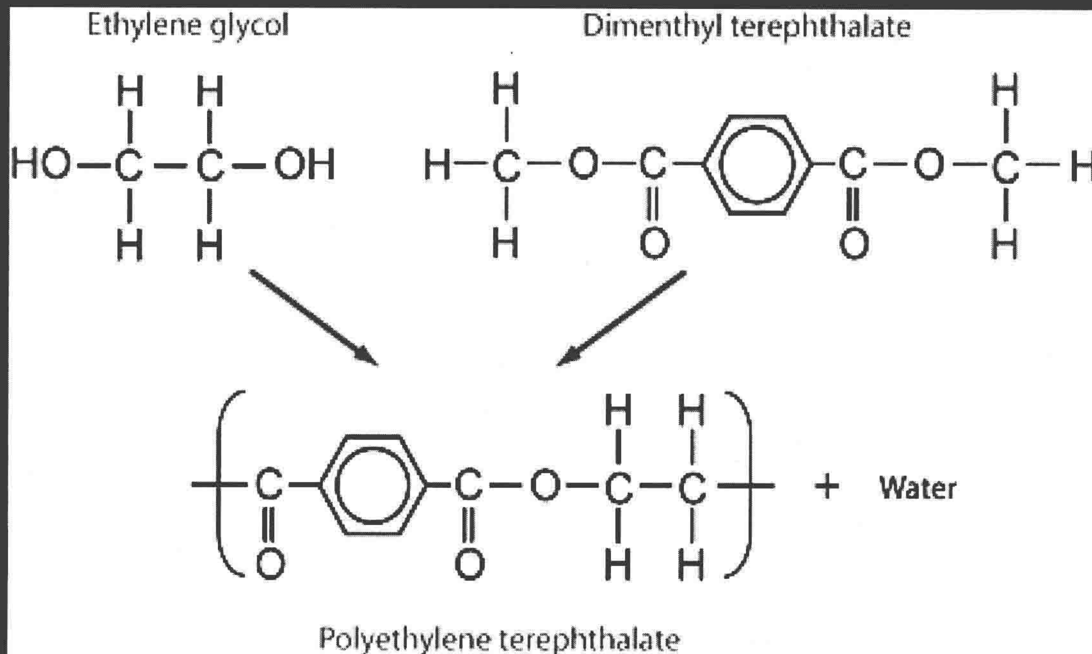
2007

European PLACE Conference

14-16 May 2007 | Athens, Greece

Chemical properties PE vs. PET

PET Synthesis



Chemical properties PE vs. PET

Polyethylene
- non-polar
- branched
- broad MWD

PET
- some natural polarity
- not branched
- narrow MWD