A TECHNOLOGICAL FRAMEWORK FOR PACKAGING FILM SUBSTRATE DEVELOPMENT

By

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Background

This paper lays out a technological framework that is structured for innovation strategies aimed at developing new Packaging Film substrates and upgrading or modifying existing ones for either new end-use applications or for delivering more functionally suitable and cost-effective products for existing applications. The major focus of this presentation is on high-end film substrates like Biaxially Oriented Polyester (BOPET) Films, Biaxially Oriented Polypropylene (BOPP) Films or Cast Polypropylene (CPP) Films.

These films are supplied as transparent, matte, pigmented or cavitated substrates that could come with coatings, metallising and/or special surface treatment if the end-use specifications so require them. They are mostly sold to Flexible Packaging Convertors who further put them through film conversion processes like printing, lamination, coating, metallisation, embossing, bag and pouch making, slitting and sheeting to produce flexible packaging structures that are ready for end-use packaging or other industrial applications.

Film manufacturers are constantly striving to turn out "specialty" products by fine-tuning, upgrading or more precisely customising existing products for established applications to give them a competitive edge on the one hand and by developing new film variants that are suitable for new end-uses to break into new markets and applications on the other. This has to be an ongoing exercise and an essential part of every progressive film manufacturer's business plan in order to overcome the inevitable commoditisation and the resultant pressure on margins that plagues all run-of-the-mill film products.

Basis for Framework

The key to success in the fiercely competitive Flexible Packaging business is identification of opportunities, understanding customer requirements in potential niche application areas and getting in there with suitable products ahead of competition with a highly focussed approach. This is why designing and laying down a technological framework for doing this is imperative and assumes cardinal importance. Furthermore, the reason why this has to be a constant and ongoing process is that the specialties of today rapidly degenerate into the commodities of tomorrow and technological edges tend to be relatively short-lived.

The technological framework design for substrate development is driven by need-based fundamentals. I would like to suggest the development and fine-tuning of a model framework by laying down the following key objectives:

a) Improved or new functional or end-use properties (including aesthetics).
b) More sustainable and "greener" products.
c) Safety and better suitability for food contact.
d) Cost reduction for end-users.

Of course, cost savings and/or improved margins and increased market share or entry into new markets will encompass all the objectives stated above.

Each of these objectives is dealt with in greater detail later together with relevant case-studies. These case-studies are based on my own experience with products that our company has pioneered.

Primary Analysis

The first step in the whole exercise is sound primary analysis.

A basic sequence of analytical activities will be as follows:

a) Identifying the opportunity.
b) Quantifying the opportunity.
c) Fully understanding all the requirements of the opportunity (e.g. functional film properties, barrier requirements for shelf-life, across-the-board machineability requirements, conversion processes involved, ultimate end-user requirements, requirements of the end-users' customers/markets, cost parameters, legislative and regulatory requirements if applicable, sustainability and end-of-life scenario etc.).
d) Translating the basic requirements into film specifications and process requirements.
e) Reviewing one's ability to produce the goods and the costs and effort involved in doing so.
f) Taking a primary "go" or "no go" decision. Quite often, the pay-off may not justify investments in time and technology even if the objective could be reasonably within reach.

Packaging is ultimately all about delivering tailor-made optimum solutions and total end-to-end system packages. It requires very close working with customers (in the case of film manufacturers - the Conversion industry) as well as with the ultimate end-users. Therefore, insight and extensive domain knowledge of every link of the Flexible Packaging value-chain are invaluable assets in this primary analysis. Our company is very fortunate in being the world's only fully vertically integrated enterprise in this business and this has been of immense help in our innovation programmes.

Let us now take up the objectives laid down as the basis for framework design.

Improved or New Properties

Film manufacturers need to constantly work on improved properties for existing film products and new properties that make films suitable for new end-use applications that will expand the usage base of the company's products. The latter includes replacement of competing flexible substrates as well as shifting applications from competing packaging systems like rigid packaging (e.g. cans, bottles) or semi-rigid packaging (e.g. cartons, thermoformed packaging) to flexible packaging systems that will use the new films developed. Quite often, it might also mean the development of a new packaging format like a single-dose package or an affordable price point pack that provides an attractive new option to the lay consumer. Flexible packaging materials and systems have immense potential here because of their light weight, optimum material use, sustainability credentials and overall cost-effectiveness. I foresee a huge opportunity by engineering an ongoing shift from existing non-flexible systems to flexible packaging systems if film manufacturers and convertors find ways to overcome existing constraints in flexible packaging materials by developing the functional properties required for this to happen.

The case-study discussed here is the development of our Twist Wrapping Grade of Polyester Film. Twist wrapping is a very demanding high-speed application that is used extensively in the Confectionery industry. Individual pieces of candy or confections are wrapped using a twisting operation on the edges of the film and it is essential that the wrapped confection retains the twist that is applied and it does not unravel. This is always a difficult criterion for a plastic film to satisfy as it tends to spring back and does not have the requisite “dead-fold” property that this entails. Moreover, the extremely high packing speeds demand that the film be static-free so that the film does not stick to the machine parts during the packaging operation. This why the only materials that met these demands for a long time were paper and aluminium foil laminates and cellophane. These were replaced by PVC films and certain grades of heat-sealable BOPP films but the latter had to use a jet of hot air to seal in the twist and this slowed down packing speeds considerably. (There was a grade of twistable BOPP film available but this was patented and could be sourced only from one manufacturer.) The task was, therefore, to replace PVC films. We were able to develop “dead-fold” properties in a new grade of polyester film with a relatively static-free surface. This enabled packing speeds to be attained that were significantly higher than those logged by PVC films or even cellophane. The additional advantage that our polyester film had was that it was easily recyclable and perceived as environment-friendly unlike PVC.

More Sustainable and “Greener” Products

With the increasing focus on sustainability, all film manufacturers are working towards development of “greener” products. Our own Sustainability programme is focused on the following objectives:

a) More efficient energy management.
b) Reducing and replacing inputs based on non-renewable resources like petroleum derivatives and substituting them with inputs based on renewable resources.
c) Establishing and maximising usage of post-consumer recyclate resins in product formulations.
d) Reducing production wastages.
e) Reusing all recyclable production waste (set-up scrap and edge trims from plain films).
f) Recovering energy from all non-recyclable production waste (generated from production of metallised films and printed/laminated films) through in-house waste-to-energy systems.

Two of the most interesting new film products that have emerged from this programme are our Green PET Films and our rPET Films.

Green PET Film is the world’s first “green” polyester product. 30% of its content is made up of an ingredient (MEG) that is sourced from renewable plant-based inputs. This agricultural input ingredient replaces one that was hitherto based entirely on non-renewable petroleum derivatives.

This innovation was initiated by the identification of a major petroleum-based input called Monoethylene Glycol (MEG) as being capable of being replaced by one derived from renewable resources. BOPET Films are made from polyester (PET) resins that are conventionally made by the polymeric reaction of Purified Terephthalic Acid (PTA) and MEG. The MEG used is manufactured from Ethanol that is traditionally produced by the hydrolysis of Ethylene, which is itself obtained by the cracking and fractional distillation of a petroleum feedstock (naphtha) or natural gas. MEG typically constitutes 30% of PET resin input.

Having established that that it is possible to also obtain Ethanol from plant sources, the next step was the developing and establishing of an MEG grade that is made from Ethanol sourced from renewable agricultural inputs. Once this source was developed, extensive trials were conducted to produce and functionally establish the suitability of PET resins and BOPET films based on this “green” MEG. We were able to do this in fairly quick time were thus able to develop a whole range of green BOPET films in all standard thicknesses and widths that have the same properties as our regular BOPET films made from petroleum-based inputs.

Our Green PET Films are approved by the FDA for food contact and conform to all EU Food Compliance Guidelines. They have won several awards for innovation.

The second example - our rPET Films - contain up to 30% PCR resin content and have the same performance properties as our standard BOPET Films. The rPET films are approved by the FDA and are compliant with all EU regulations for safe food contact. These films are available in all standard thicknesses, widths and variants.

Our basic film production process is already a virtually “scrap-free” operation. In order to further recycle more PET resin, we undertook a fresh exercise to source post-consumer PET recyclate (PCR) resin and to establish its usage to the extent possible in our regular film production. As there is substantial waste generated by used PET bottles and industrial film scrap which is sent to landfills, we decided to facilitate conservation of scarce non-renewable oil reserves by recycling some of this. The PCR resin sourced by us is made by the tertiary chemical glycosis of PET resin from post-consumer waste like used PET bottles and industrial PET film scrap.

The development challenge was to adjust our process conditions to be able to maximise the usage of this PCR resin and to maintain film properties that delivered the same performance as our regular films made from “virgin” PET resin. The development of rPET Films has enabled us to substantially reduce our consumption of virgin PET resins and replace this quantum with recycled PCR PET resin without sacrificing on film quality and suitability for food contact. The development of rPET Films has helped us to potentially eliminate many thousands of barrels of precious non-renewable petroleum crude from our product life cycle and to concurrently recycle a lot of post-consumer waste polyester products that would otherwise have to be consigned to landfills.

Safety and Better Suitability for Food Contact

Many developments are driven by the need to make films safer and more suitable for food contact. An example I would like to cite is our recent development of an antimony-free polyester film. Antimony is conventionally used as a catalyst in the manufacture of PET resins in the form of either antimony trioxide or antimony triacetate and all PET resins and films normally have a residual content of the metalloid or its compounds which are considered toxic ingredients. They usually leach out particularly in contact with liquids or when packs are subjected to microwaving or boiling. Although the residual content and extraction levels are well below the maximum levels that are considered safe for human consumption, their presence is nevertheless a source of concern especially for products like drinking water and fruit juices. The attempt of all film manufacturers has, therefore, been focused on developing polyester films that are free from antimony. We have been able to develop antimony-free products across our entire range of polyester film variants.

Cost Reduction for End-users

Film manufacturers need to constantly work on delivering cost savings to end-users. This can be done by developing new products altogether or by modifying existing products so that they run better. Sometimes, it may even extend to designing modifications to conversion equipment or to end-user packaging machinery to enable cost savings by way of higher throughput or lower wastages.

One of the most fruitful exercises for cost reduction has been by way of reduction in film thicknesses for existing applications or “downgauging” as it is in the industry. Over a period of time, film manufacturers have been able to bring down thicknesses by as much as 20% or more without sacrificing functional properties or machineability of the substrates. The key to successful downgauging lies in ensuring that barrier and operational properties like web handling capabilities are not compromised and at the same time ensuring that the manufacturer himself does not lose out on output rates and extra wastages while producing lower film thicknesses.

Another case study I would like to cite is that of our extrusion coatable polyester film. Extrusion coating and lamination are the preferred processes that are used to produce multilayered flexible packaging laminates because of their higher operating speeds, elimination of a dry lamination operation and of the expensive adhesives involved therein and the VOC emissions that ensue and for the superior flex and surface properties achieved in the laminated structure. Traditionally, this operation needed the use of a primer coating to deliver the requisite bond strength. This new film makes it possible to extrusion coat or laminate it without the need to prime the surface because it’s surface has already been modified to make it suitable for high bond strength to be obtained without the priming operation. This also delivers operational flexibility, simpler equipment design and significant savings in costs for convertors.

Conclusion

To sum up, the technological framework for substrate development has to be a need-based structure which also needs to be constantly reviewed and altered as necessary to keep up with up-to-date requirements.