Thermoforming Quarterly®

A JOURNAL OF THE THERMOFORMING DIVISION OF THE SOCIETY OF PLASTIC ENGINEERS

FOURTH QUARTER 2009 ■ VOLUME 28 ■ NUMBER 4

INSIDE . . .

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A. Schulman Launches Invision® Enhanced Polyolefin Resins for Sheet and Thermoforming Markets

A. Schulman, Inc. introduces a family of high-performance Invision® enhanced polyolefin resins for sheet producers and thermoformers.

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Editor
Conor Carlin
(617) 771-3321
cpcarlin@gmail.com

Technical Editor
Barry Shepherd
(905) 459-4545 Ext. 229
Fax (905) 459-6746
bshep@shepherd.ca

Sponsorships
Laura Pichon
(847) 829-8124
Fax (815) 678-4248
lpichon@extechplastics.com

Conference Coordinator
Gwen Mathis
(706) 235-9298
Fax (706) 295-4276
gmathis224@aol.com

Cover photo courtesy of European BioPlastics

Brian Ray

The Society of the Plastics Industry (SPI) and its member companies define sustainability as a balance of protecting the natural systems of the planet, providing high quality of life for all people, and fostering global competition, economic freedom, and growing prosperity for all. SPI advocates continuous innovation and improvement in applying sustainability principles in the manufacturing, distribution, use and disposition of plastic materials. The Thermoforming Division is committed to providing its members with information, data and educational opportunities that will have a positive impact on the (triple) bottom line. In this issue, we offer a foreword by board member Phil Barhouse of Spartech Packaging Technologies.

Brian Ray
Chair

Facing the Sustainability Challenge

Within the thermoforming industry, there continues to be confusion and challenges regarding sustainability and understanding the complexity of sustainable solutions. These complexities are broadened by the significant volume of misinformation and green-washing campaigns based on loose or unsubstantiated claims. There are several challenges facing thermoformers attempting to implement sustainable programs aimed at creating environmental benefit while providing value to their customers. To achieve this level of success requires a comprehensive strategic program that covers all aspects of sustainability. Today's thermoformers will benefit from a strategic approach to implementing sustainability within their organizations and an in-depth understanding of sustainable material attributes and solutions.

Benchmarking sustainability programs from leading companies such as Proctor & Gamble, SC Johnson and HP gives us a better understanding of how these strategic programs are constructed. You may also consider companies within our own industry. For example, Spartech's Corporate Sustainability program consists of four pillars: Environmental, Health and Safety, Social Responsibly and Technology. The Environmental team focuses on reduction of the corporation's footprint through energy, waste and GHG emissions management. The Health and Safety pillar involves the certification of each plant to Spartech's Health and Safety management system. The Social Responsibility group gives back to the community through volunteerism and charitable giving. The final area, Technology, looks at bringing new, more sustainable materials to market. These materials may involve bio-renewable, recycled and or recyclable products. Together, these four pillars were developed not only for the benefit of our internal sustainable programs, but also our customers' programs.

Using accredited resources available today through industry and trade connections, thermoformers can drive value to implement a successful strategic sustainability program. The SPE Thermoforming Division, through its Board, technical committees and this publication, is committed to providing those resources to its members. In this issue, you will find several articles that are specific to sustainability and thermoforming and we hope you will find them informative and helpful as you develop your sustainability platform.

~ Phil Barhouse
Spartech Packaging Technologies

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Jacuzzi Europe Spa
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Bio4Pack Offers One-Stop Shopping

Editor's Note: This story first appeared in "Bioplastics Magazine," Vol. 4, 2009. It is reprinted here with kind permission of the editor, Dr. M. Thielen.

Two Dutch thermoforming companies, Nedupak Thermoforming (Rheden, Netherlands) and Plastics2Pack (Uden, Netherlands), recently announced the formation of "Bio4Pack," a new packaging supply company. The new entity is headed by Managing Director Patrick Gerritsen, who brings with him several years of expertise in the area of bio-based and biodegradable packaging.

Bio4Pack not only offers thermoformed packaging but also various other kinds of packaging made from bio-based and/or biodegradable materials including films, bags and netting. They also offer sugarcane trays made from bagasse, a by-product of sugar manufacturing.

"We want to offer our customers a total packaging solution," says Oliver Fraajie, Commercial Director of Nedupack, "not just a thermoformed tray or bulk pack." The portfolio of Bio4Pack comprises the traditional thermoformed packaging made from bioplastics such as PLA and other new thermoformable materials.

The range also includes films and bags for all kinds of purposes, e.g. shopping bags or flow wrap packaging made from starch-based bioplastics such as Biolice®, Materbi® or Bioflex® from FKUR, as well as nets for produce and labeling materials.

"We also offer meat packaging consisting of a thermoformed PLA tray with peelable SiOx coated PLA film, having the same properties as conventional packaging," adds Frank Eijkman, Managing Director of Plastics2Pack. "And for bakery goods such as cakes and cookies we have thermoformed trays and folded boxes from a more rigid PLA sheet. This kind of box is also available for the packaging of bio-chocolate, for example."

Blisters for liquor gift packs or batteries round of the list of examples. "In a nutshell, we are a trading company that offers all types of packaging made from bio-based or biodegradable materials," says Gerritsen. "Those that we don't produce ourselves at Nedupack or Plastics2Pack, we get from partners."

All products are certified according to EN 13432 and Gerritsen goes one step further: "We are investigating the possibility of having our products certified and labeled "Climate Neutral" (www.climatepartner.de).

Bio4Pack started operations in August and has received orders from leading companies in the fresh produce and supermarket industries. While the company plans to begin marketing in Europe, clients from all over the world can be served by Nedupack's partners in many countries. Nedupack has the added flexibility of internal design and tool-making departments which allows for fast reaction times.

Although the new company was founded during difficult economic times, the entrepreneurs have full confidence in the development of this market. "We are looking forward to convincing more and more supermarkets and other suppliers to switch to bioplastics, and not only because traditional sources are finite," says Gerritsen. Fraaije is convinced that "the customers who buy bio-food are also willing to buy bio-packaging." |

REDUCE!

REUSE!

RECYCLE!

REDUCE!

REUSE!

RECYCLE!

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Automatic Savings Plan

Chris Parrillo, Yushin America, Inc.

As competitive forces rapidly accelerate, most thermoformers agree that automation is the key to maximizing savings. Today, thermoformers apply direct and indirect labor to remove, test, package and transfer parts throughout their organization. In order to remain competitive, thermoforming companies must reduce these costs as much as possible, while continuing to increase quality and productivity. The best way this can be accomplished is through the installation of automated work cells that employ high-speed servo robots.

Forces Driving Automation

While costs associated with manufacturing products in the United States continue to grow at an exponential rate, thermoforming companies must continually work to minimize their expenses. Companies are being asked not only to produce quality parts at costs competitive with low wage countries, but also to lower costs over the life of their contracts. Robots have consistently provided an immediate impact on reducing labor costs while increasing productivity and quality.

Robot Configuration

The advantages of the Cartesian-style servo robot include configuration, speed, accuracy, reliability, ease of use, and flexibility. A Cartesian or linear robot is an industrial robot whose three main axes (X, Y, and Z) are linear so they move in a straight line rather than in a rotational movement like an articulated robot arm.

The main advantage of the high-speed servo robot over other types of automated work- handling systems is that a servo robot is capable of quickly driving to any point along its three axes while constantly monitoring and correcting its position. Robots are fast and flexible and they can be quickly and easily reprogrammed or retooled. The linear design of the Cartesian-style robot has proven to be extremely effective for the extraction and stacking of thermoformed parts.

Robots can be configured to run parallel with or perpendicular to the sheet line. The robot mounting frame and integrated safety guarding are designed in a way that allows seamless integration to the existing machine design. The direct linear motion of the robot matching the product flow offers simplicity of controls and programming with high-speed motion.

The robot interface creates a 'handshake' with the thermoforming machine and it is programmed to wait directly above the sheet line to pick the formed products. The robot is capable of accurately tracking the sheet as it is fed from a trim in place machine or picking trimmed products from an up-stacker, a machine bed, or a conveyor.

Speed and Efficiency

Robots employ ultra high-speed motors on all three axes and incorporate rounding motions into the automatic stacking routines to achieve 17-20 cycles per minute (depending on the part geometry and strokes). Reliable, consistent, controlled part handling reduces scrap rates and part count errors.

Robots utilizing belt-drive technology and sealed bearings require minimal lubrication and can run non-stop for extended periods of time. A robot with a clean operating design is essential for success in high-spec, cleanroom applications where food and medical products are produced.

Ease of Use

One of the characteristics a robot controller offers is an easy-to-use graphical operator interface. The design of the controller is balanced to incorporate cost, operator interface, programmability, capacity for data storage and future expandability. The interface should allow all functions to be accessed and understood with minimal training and a short learning curve. The controller incorporates functions that include set up, troubleshooting, cycling and monitoring.

The graphical interface allows the user to operate the robot without having any previous robot controller experience. The graphical interface displays robot and other important functions on the screen, greatly reducing training, downtime and changeover/set up times. Technical staff can easily perform mold changes, machine setup or creation of new sequences or programs.

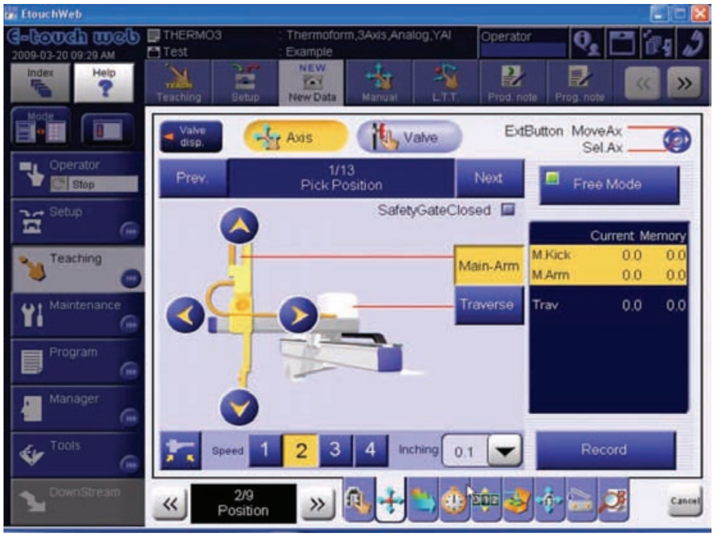


Figure 1. Screen shot of graphical interface showing robotic axis.

Mold data (positions, speeds, and timers) is stored for quick retrieval of sequences, thus eliminating the need for reprogramming. However, robots can also be easily reprogrammed or retooled offering reduced mold changeover times and short production runs.

End-of-arm tooling can be designed to either handle several different products (adjustable) or to be dedicated. Adjustable tooling can be a cost-effective alternative to having dedicated end of arm tooling for each product or mold. The robot is equipped with programmable stack height, 180-degree rotational stacking or A/B/C stacking capabilities.

Thermoformers must continue to use technology and automation to achieve higher quality at a lower cost. As thermoformers increasingly embrace automation, competition for new work will depend on the ability to compete and bid for new jobs. Using automation to remain efficient and keep up with competitive forces will be an essential element of survival for thermoformers both now and in the future.

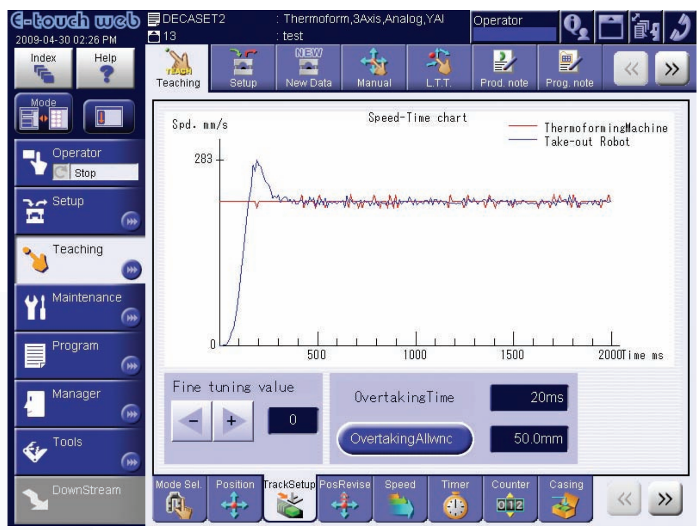
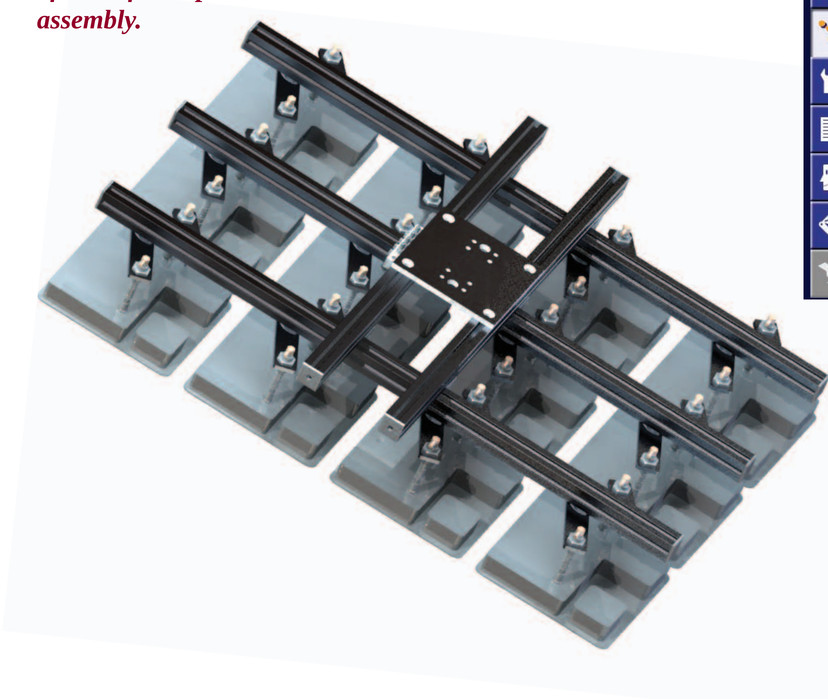


Figure 2. Screen shot of graphical interface with training function.

Figure 3. 3D rendering of end-of-arm picker assembly.



The Business Case for Sustainability

Margaret H. Baumann, G.H. Associates, Lebanon, NJ

(Editor's Note: This paper was first presented at NPE 2009. It is reprinted here with the kind permission of SPI.)

Abstract

This paper will try to establish a business case for sustainability by defining "sustainability" as a net energy reduction when an LCA (Life Cycle Analysis) is done. This means we must reduce our overall footprint (carbon and ecological) in terms of how much of the earth's resources we use and how much damage we leave behind. By making this the strategic objective sustainability becomes "good business." If we take this objective seriously what are the implications for the plastics industry?

Introduction

In the last couple of years the words "sustainability" and "green" has become part of the mainstream vernacular. Manufacturers, marketers and consumers are all taking a more serious look at the meaning of "sustainability" in their business plans. There are still a lot of misconceptions regarding just what sustainability means. How do you define sustainability? What does having a neutral or negative carbon footprint really mean and why does it matter?

In 1789 Thomas Jefferson wrote the first definition of sustainability. "Then I say the earth belongs to each generation during its course fully and in its own right. The second generation receives it clear of the debts and encumbrances, the third of the second, and so on. For if the first could charge it with a debt, and then the earth would belong to the dead and not to the living generation. Then, no generation can contract debts greater than may be paid during the course of its own existence. Jefferson's quote was updated for our times in 1987 when Gro Harlem Brundt restated it as " … [our] generation must meet the needs of the present without compromising the ability of future generations to meet their own needs." Right now, due to the perfect storm of geo-political events, our generation must take seriously the need and advantage of the opportunity for more sustainable usage of our resources.

In the book, *Hot, Flat and Crowded*, Thomas Friedman makes the case for "why we need a green revolution and how it can renew America." The first half of the book is a diagnosis of the unique energy, climate and biodiversity challenges the world faces. Friedman suggests the world is getting hot, flat and crowded due to tightening energy supplies, the intensifying extinction of plants and animals, deepening energy poverty and accelerating climate change. The second half of the book is how we can meet those challenges. The challenges he describes effectively in the book are an opportunity for America and especially the plastics industry. America is always at its most powerful and most influential when it is combining innovation and inspiration, wealth building and dignity building. We agree with Thomas Friedman's thesis that it is hard to imagine an acceptable solution to the issues our earth is facing without the leadership of the U.S. politically, technically and economically. We have the opportunity to become the world's leader in innovating clean power, energy systems and renewable materials. By addressing these three areas in earnest we can begin to solve the problems facing out world today. Although the plastics industry alone does not hold the keys to all the solutions, it certainly can play a major role and it is important for our industry to continue to contribute to innovation in this area.

Energy

Even though the price of a barrel of oil has decreased since early 2008, the pressure should remain on short-, medium- and long-term strategies to reduce the amount of energy we use. Short-term we need more sources of domestic oil. However, we cannot retain short-term thinking here. We need to plan and develop alternative energy sources- these are areas that the plastics industry is already contributing to as part of the solution.

For example, DuPont and others are working on solar cell technology to both improve its performance and cost. Polymer technology is one of the most promising of the fuel cell approaches. Polymer composites contribute to wind turbine manufacturing, another technology being used as an alternative energy source. One of the biggest challenges facing our planet is finding ways to convert our conventional industrial processes that use non-renewable feedstock into processes that are eco-efficient. At present, more than 85% of the United States' energy supply is fossil-based with less than 4% coming from solar, wind, geothermal and biomass, 8% coming from nuclear and 4% coming from hydro.

Currently hydro energy constitutes almost half (48%) of the renewable energy used in the U.S., but that figure is expected to decline as concerns over water shortage continue. The next largest segment is biomass (44%) comprised primarily of lumber company waste. In Friedman's book, he describes the utilities industry (the largest user of oil as an energy generation source) as being at an energy "all you can eat" buffet. He recommends that the utilities industry of the near future should be more demand-based, i.e. incentives should be in place to make the industry more sensitive to demand inputs. He suggests that a solution would be smarter systems or those that recognize lower periods of electricity demand and run their functions then. Energy efficiency should be the goal of any technology developed for the market today. We should not fund technology that doesn't promise a reduced carbon footprint or net energy efficiency. The plastics industry has the know-how to help in this area as well. Friedman concludes that we are entering a new Era of Energy where we need to focus our technology research on solutions for managing both the increasing global energy requirements and the continuing stewardship of the earth for future generations.

Green Chemistry and Carbon Footprint

A report written by the DOE and USDA in 2001 highlighted the need not only for investment by public/private partnerships but also for the use of integrated R&D to foster innovation in bio-based materials. Currently there are more than 250 companies in the U.S. producing a variety of bio-based products. A number of these companies were fostered by the federally mandated use of recycled products and by the low cost agricultural availability of the starting materials. Conversion to bio-based products would provide more income to agriculture and forestry producers and processors. It offers one more tool to conventional approaches to materials and energy.

European BioPlastics estimates that annual global production of bio-plastics will increase six-fold to 1.5 million tons by 2011, up from 262,000 tons in 2007. The volume in 2007 includes bio-renewables as well as bio-based. This will still be only about 0.7% of the Petrochemical-based plastics used today. The table below lists the current producers of bio-based plastics.

Bio-based Definitions

One recent challenge has been to develop common standards and definitions for bio-based products. For a product to be bio-based, it must be organic and contain in whole or part carbon from biological sources as opposed to petrochemical based carbon. As shown in Figure 2, the C14 signature forms the basis for identifying and quantifying bio-based content. Plants and animals that utilize carbon in biological food chains take up C14 during their lifetimes. As soon as the plant or animal dies there is no replenishment of radioactive carbon, only decay. Since the half life of carbon is around 5730 years, the fossil feedstocks formed over millions of years will have no C14 signature. By using this methodology one can identify and quantify bio-based content. ASTM has developed test method D6866 for bio-based content.

Product	Company	Location	Capacity/mtons	Price/lb.
PLA	Natureworks	USA	70,000	0.80-1.10
PLA	Hisum	China	5,000	1.25
PHA	Metabolix	USA	300/50,000(2009)	2.50
PHA	Meridian	USA	150,000 (est.)	n/a
PHBV	Tianan	China	2000	2.40-2.50
Materbi	Novamont	EU	75,000	2-3
Cereplast	Cereplast	USA	25,000	1.50-2.50
HDPE	Braskem	SA	200,000 (09)	0.80-1.00

Source: Jim Lunt and Associates LLC

PLA - Polylactic Acid Polymer; PHA - Polyhydroxyalkanoates; PHBV - Polyhydroxybutyrate-co-hydroxyvalerate; Materbi (Starch); Cereplast - compounder of starch and PLA blends; HDPE - High Density PE

Reducing the Carbon Footprint Using LCA (Life Cycle Analysis)

Life cycle analysis is a good way to quantify and measure the sustainability of products. ISO 14040 or ASTM D7075 standards address LCA. LCA involves the compilation of a comprehensive inventory (Life Cycle Inventory or LCI) of relevant inputs and outputs of a production system. This involves an organized effort to measure specific input components contributing to the production and delivery of the material to its end-use application. In addition, an LCA requires an evaluation and assessment of the environmental impacts associated with the processes. LCA represents the best method available to help define R&D goals and economic and environmental targets. R&D on current bio-based polymers needs to be focused on continued reduction of the carbon footprint either through energy efficiency or raw materials which have a smaller carbon footprint. Figure 3 compares the carbon footprint for PLA and where the research on PLA is aimed at reducing its carbon footprint. Figure 4 illustrates what is expected when bio-based PP is compared to current petrochemically based PP – there is a significant reduction in CO_2 emissions.

Industrial Biotechnology

Lower capital expenditures, lower raw material costs, the ability to create new functionality and the promise of low environmental footprint are all potential benefits which are motivating the increased research in the field of biotechnology and industrial chemicals. Even though

(continued on next page)

chemicals and plastics only account for about 13% of fossil fuel usage, it offers the promise of reduced carbon footprint by replacing old carbon with new carbon. Both Dow Chemical and Braskem (Brazil) are planning to bring bio-based polyethylene plants (sugar cane bagasse) by 2009-2010.

The benefits of industrial biotech are numerous. In addition to reduced dependency on oil based derivatives, bio-technically based chemicals and polymers have faster cycle times, low cost bio-feedstocks, more efficient bio-processes and more means of production than conventional processes. The bio-based materials however have different handling characteristics. Some commercial products that use bio-energy or are bio-based products include bio-polymers (PLA, PDO, and PHAs), fuel (bio-ethanol), chemicals (ethyl lactate, succinic acid and lactic acid) and lignin. Experts believe that biotechnology will play a big role in many markets-drugs and vitamins, textiles, leather, pulp and paper, mining, metal refining, electro-plating, molded goods, film packaging and fibers. Industrial Biotechnology is becoming attractive from a business perspective because it:

- Decreases production costs
- Increases sustainability profile
- Allows broader use of agricultural feedstocks instead of petroleum
- Provides precision catalysis
- New bio-catalysts constantly being discovered
- Not controversial like medical biotech
- Bio-based polymers with enhanced or added value properties

The continued research in making bio-based materials more valuable is centered on the utilization of non-food based raw materials like biomass and alternative energy for powering the plants contributing to the successful management of the carbon footprint.

Conclusions

The Plastics Industry has and needs to continue to contribute to "sustainable products and systems". Polymer solutions continue to improve alternative energy technology whether solar, wind, fuel or other alternatives. Recycled content polymers and composites contribute to energy savings and raw material efficiency. Bio-based polymers continue to improve in their performance and reduced carbon footprint. R&D needs to remain focused on net energy efficiency and Life Cycle Analysis (LCA) as tools to measure the progress of sustainable solutions.

In our current environment and world role, the US plastics industry needs to make sustainability "good business" by addressing the multiple challenges of energy sources, climate change and growing middle class. We need to keep this front and center as we decide where we focus our human capital and resources.

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Keywords

Sustainability, Reduced Carbon Footprint, Alternative Energy, Bio-based Polymers

Figure 1.

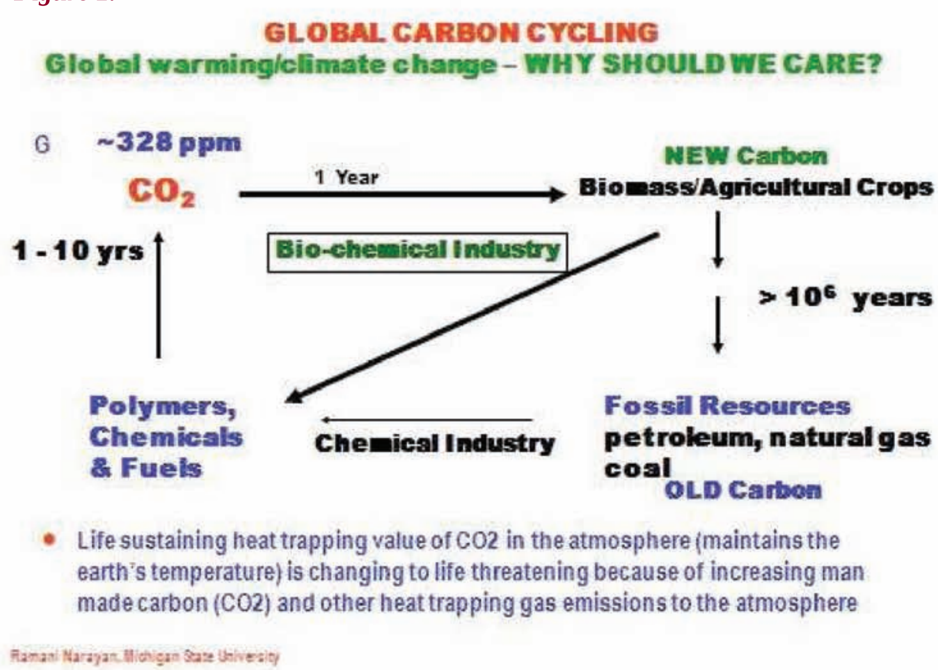


Figure 2.

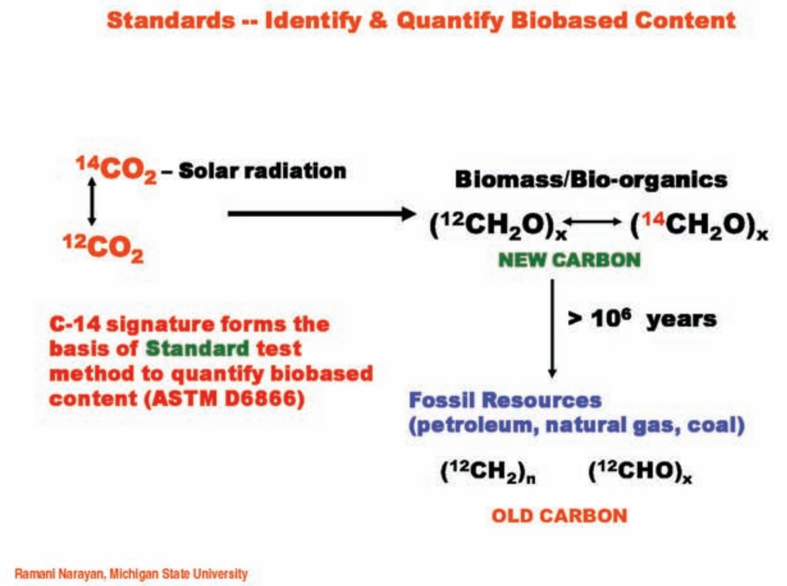
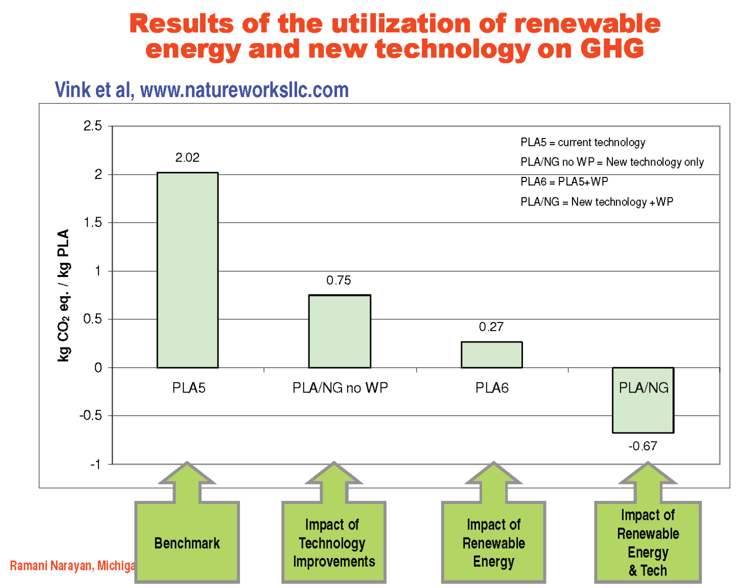
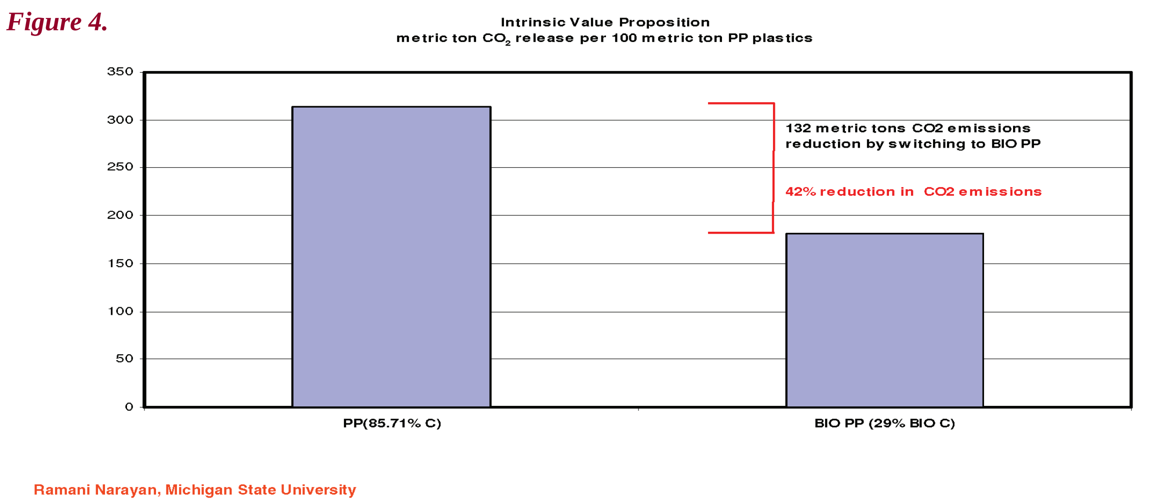


Figure 3.



GHG- Greenhouse gasses

Figure 4.



Ultrasonic Sealing and Cutting in Thermoforming

Sven Engelmann, Gerhard Schubert GmbH, Germany

Abstract

In common thermoforming, filling and sealing applications the processes of sealing and cutting are performed in two separate steps. In order to combine sealing and cutting in one station a new device has been developed employing ultrasonic technology so that both functions can be executed simultaneously. The ultrasonic sealing and cutting station reduces sealing times, cutting forces, wear and tear as well as floorspace, facilitating fast format changes. Contaminated rims can be sealed without compromising the sealing integrity and thus preventing any exposure to the atmosphere so that neither food items are permitted to spoil nor medical items loose their sterility. This device provides data for logged sealing quality and is linked with the control system of the entire packaging line.

Introduction

When in the past Schubert robotic pickerlines were linked inline with thermoform lines and sealing stations the F44 robots could not attain their full efficiency. The intermittent mode of operation of the thermoform module and the sealing station impeded the continuous run of the packaging film and the trays moulded therein.

The newly developed TLM-FFS works with moving and repeating forming (TLM-TF) and sealing/cutting modules (TLM-TS). The reciprocating modules facilitate a continuous running of the packaging film and thus the efficiency of the pickerline increases.

Principle of the forming, filling and sealing operation:

- unrolling of the film
- heating of the film
- forming of the film in order to create form parts
- filling
- sealing
- cutting
- removing of the pack

A Schubert TLM-FFS line therefore consists of a TLM-TF, a pickerline and a TLM-TS.

The continuous motion of the film is not the only characteristic worth mentioning of the TLM-FFS. The line also facilitates an automatic change of the film roll, meaning that if the film of a roll is exhausted during operation, the film of a second roll is fed automatically to the line. Whilst the film of the second roll is being thermoformed the first film roll can be replaced.

In the forming station the thermoform process can be effected by using compressed air and/or vacuum. All thermoformable packaging plastics can be processed. The application spectrum comprises soft packs as well as hard packs.

Sealing is done with ultrasonic method. This entails slightest thermal exposure which results in minimal sealing times. Furthermore even unclean sealing surfaces can be tightly closed. The sealing station also serves as cutting station. The plastic pack is separated from the film by an ultrasonic-sealing/cutting tool. Cutting by ultrasound requires less punching forces than conventional cutting which therefore requires less elaborate punching presses. The result is less wear for tooling and machine modules.

Development

It is necessary that the working stations move with the same speed as the packaging film in a synchronised movement until the working cycle is completed in order to facilitate the continuous running of the film. Then the station moves contrary to the direction of travel of the film back to its point of origin and thereafter a new cycle starts. This requires the use of light weight units in order to make fast movements possible. For conventional thermoforming high cutting pressures need to be applied and they require solid punch presses. If sealing is done as a first step then the pack which has to be sealed must be put under pressure and exposed to heat in a press. So the task was the development of a light weight unit which is able to punch the usual cutting line lengths with slight cutting pressures. Cutting and sealing of the packs should be done simultaneously in the projected station in order to develop space-saving machines. The quick exchange of the sealing/cutting tools was another demand.

For conventional thermoforming the cutting pressures can be lessened to a certain extent by, for example, warming the steel rule die of the cutting edge or warming the thermoform film. Resulting from this realisation the procedure of warming the plastic material during the sealing and cutting process only at the points where heat is really necessary was examined in detail. This heat is only generated for the time of the sealing and cutting process by applying the principle of ultrasound.

Principle of Ultrasound

Sound waves above the limit of audibility are called ultrasound. [1]. A generator converts the mains voltage (50Hz) in high frequency AC tension (20000 or 35000Hz). This AC tension is conducted to the converter by a shielded high frequency cable. Using the piezo-ceramic effect the converter transduces electrical oscillation into mechanical oscillation. Ceramic disks are loaded with high frequency tension. Dependent on the frequency, the alternating current generates a continuously alternating change of length – the amplitude. To transform the oscillation to the sonotrode (horn) a so-called booster is used. The booster also acts as a transmission. Certain transmission ratios are responsible to increase or decrease the amplitude. Maximum amplitudes are around 30 µm. Converter, booster and sonotrode form an oscillation unit (Figure 1). A certain number of oscillation units create a flat surface under which almost any geometry can be sealed and cut. This is leading to format flexibility. The anvil is the counter support of the sonotrode. It is shaped to focus the energy in the cutting as well in the sealing area. The focus of the energy is achieved by energy directors.

Due to the energy directors underneath and the oscillating sonotrodes above, lid and bottom film create heat when ultrasound is applied. The heat is only created where it is necessary and only for a short time.

Results and Discussion

Combining all oscillation units to obtain an even and flat surface of 400mm by 300mm under which almost any sealing and cutting geometry can be achieved, requires some measurements. For instance, the device needs to guarantee that the amplitude distribution is always the same across the complete surface (Figure 2). Especially when applying press pressure. After the sealing and cutting process the station has to divide itself to release sealed and cut packages. This enables the unloading robot to pick up the packages and send them on their way to the final packaging station.

Concerning sealing and cutting time the system provides fast cycle times. All applications achieved so far required sealing and cutting times in the range of 200ms to 500ms (Figure 3). Common forming, filling and sealing applications require sealing times between 1s and 1,5s.

Most important is the decrease of cutting force in comparison with steel rule die. For example a cutting line length of 1810mm for A-PET sheet (thickness: 450µm) requires using the steel rule die process (cold) according to [2] a cutting force of 20,7t. Cutting the same length with the ultrasonic cutting station requires 1,2t. That is 17,25times less (Figure 4).

Cutting edge and sealing area of the anvil need to be adjusted to the thicknesses of the bottom and lid films.

Fast format changeovers are possible with this system. Since the ultrasonic equipment belongs to the machine (generators and oscillation units) only the anvil has to be changed. In comparison to other ultrasonic systems the ultrasonic equipment does not have to be changed when switching to another format.

When applying ultrasound so that the tool cuts through the sheet, contact between anvil and sonotrode has to be avoided and this makes the use of a protection film necessary. Depending on the application this protection film can be made of paper, paper/polymer laminate or polymer.

When dealing with oscillation and amplitudes in the range of a few micrometers the press has to be precise in plane parallelism. Tolerance in other directions can be rather high which makes the operation in rough environment easy.

Conclusion

This development resulted in the creation of a new sealing and cutting device for thermoforming machines. It can be used for forming and cutting applications as well as for forming, filling and sealing / cutting processes. The station enables fast format changeover. Low press pressure is required and therefore the presses can be built in smaller dimensions. Less wear and tear occurs due to the fact that the material heats up in the area of the energy directors when applying ultrasound. The equipment is designed to allow automatic unloading of packages and trays (Figure 5). The energy input during sealing can be controlled. The machine control system will reject packages which were not sealed with energy within a pre set operation window. The protection film avoids a complicated sonotrode system, enabling to use the same sonotrodes for all formats. This development has certainly helped to make automated packaging lines more efficient.

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Key Words

Thermoforming, Sealing, Cutting, Punching, Ultrasound, Ultrasonic, Frequency, Steel rule die

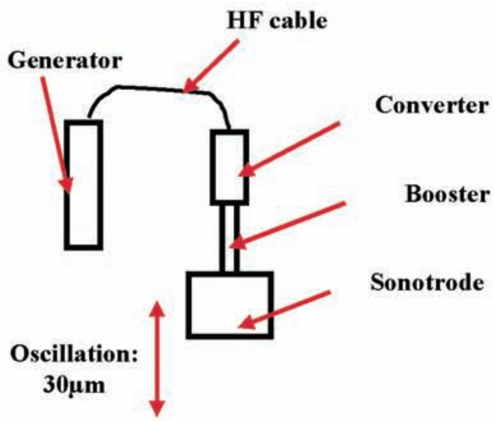

Figure 1. Generator and oscillation unit.

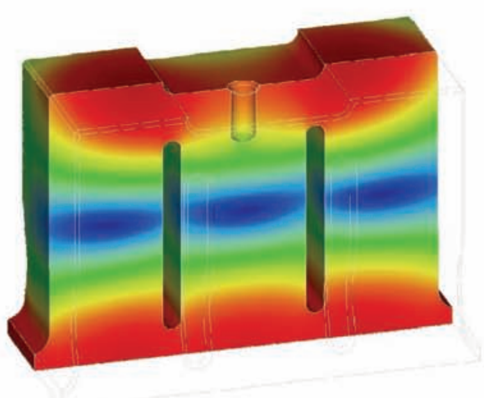

Figure 2. Amplitude distribution of sonotrode.

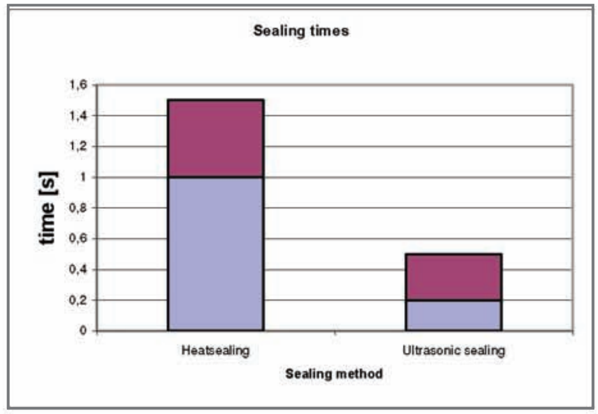

Figure 3. Sealing times.

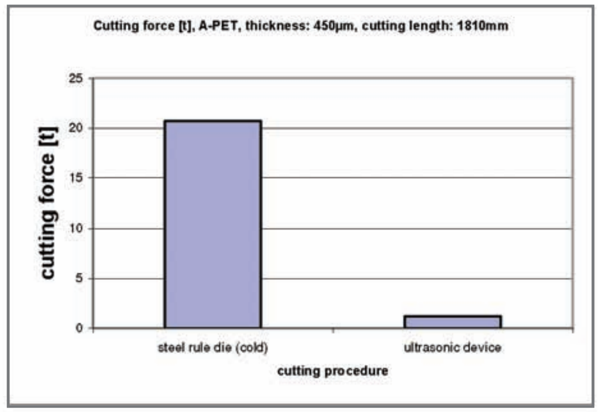

Figure 4. Cutting forces.

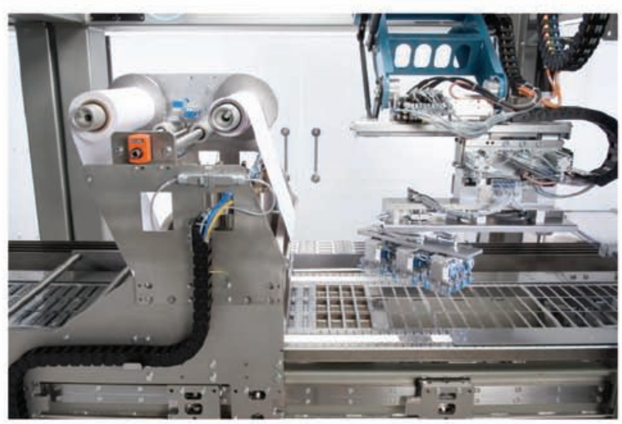

Figure 5. Ultrasonic sealing and cutting station, automatic unloading of punched trays.

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This PET's a Big Blue-Box Problem

But moves are afoot to get thermoform PET containers into the recycling system

Ellen Moorhouse, freelance writer for the *Toronto Star*

Technical Editor's Note: This article appeared in the Toronto Star *on October 3rd, 2009. Thanks to the author Ellen Moorhouse (a freelance writer with a regular column under the title of "Trash Talk") for allowing us to print it here, unedited. It is common for us all throughout North America to include thermoformed PET packaging in our municipal recycling bins along with pop bottles, however until optical sorters are installed to separate polymers reliably, clamshells and trays are not accepted in the mainstream recycling facilities. This article is somewhat misleading in that it says the problem lies with the clamshell PET mixed with the bottle PET which creates inconsistent quality for bottle blowmolders. This may be the case, but the bigger problem is that other clear materials such as OPS and PVC can get mixed with PET intended for thermoform sheet extrusion which can cause considerable machine down time. As she reports here, one southern Ontario thermoforming company is investing big money to capitalize on the opportunity to recover the packaging that might otherwise get into landfill. Other companies in the United States are doing the same.*

Okay, so what's the story about PET or PETE? That's the plastic in water and pop bottles with a "1" in the recycling triangle on the bottom. Its name: polyethylene terephthalate.

Many clear plastic berry boxes, lettuce bins and egg cartons are made out of PET, too, although the molecular structure is different. They are manufactured by a thermoform process in which PET film is pressed into shape, while bottles are made by blowing air into a tube, forcing the hot plastic against the sides of a mould cavity.

(Some clear containers are actually polystyrene – a crystalline version of packing foam and meat trays – and are labeled PS with a number 6, leading to even more blue box challenges.)

Every time I mention that the clear plastic berry boxes, salad bins and egg cartons aren't recyclable, I receive distressed emails from readers. Municipalities get the same feedback.

"Virtually every day we get people calling, wanting to know why we don't collect it," says Willma Bureau, contracts and collection supervisor for Simcoe County. "There's a lot of pressure on us, but we made a conscious decision not to collect materials that can't be recycled in North America."

Toronto, Peel, Durham, Hamilton and Halton also don't want the thermoform containers.

Next year, things may change. Brampton-based Par-Pak Ltd. is importing $2.5 million worth of equipment from Europe that will pelletize and decontaminate both bottle and thermoform PET for reuse in food-grade containers. The company makes cookie trays, deli and salad containers, bakery items and disposable take-out containers.

Par-Pak's vice-president of sales, Glen Armstrong, says the equipment will be installed and operating early next year. It will have the capacity to process close to 12 million kilos annually, which is a lot of clamshells.

"We're going to be the first company in Canada to do this, although there are companies taking the same path in the U.S.," says Armstrong.

Sorting tests have been conducted at Toronto's Dufferin recycling plant and in the Region of Waterloo and the thermoform bales have been shipped to the U.S. for processing south of the border.

So what distinguishes bottle and thermoform PET?

"There's a difference in the molecular weight," says Fred Edgecombe, a PhD and technical consultant to the Canadian Plastics Industry Association. He's worked in plastics since the 1950s.

"The molecule is not so long in the thermoform material as it is in the bottle resin. That makes it an easier material to process in thermoforming."

If the two kinds of PET get mixed, the material, with its basic chain of carbon, hydrogen and oxygen atoms, must be processed to achieve the proper viscosity, involving reactions and substances with impressive names: esterification, polycondensation, ethylene glycol and dimethyl terephthalate.

Decisions surrounding recycling depend on three things: markets, the ability to sort it, and consumers' willingness to recycle it.

For thermoform PET, the problem is marketability and sortability. It can be picked off using optical sorters that identify PET but if you're sorting manually, how do you distinguish between PET and other clear containers as they fly by on a conveyor?

"My customers won't take anything that isn't bottle grade material," says John Baldry, who manages Toronto's recycling facilities.

Some thermoform does get through, and he says he'll lose his customers if there is too much of it in the bales.

He sympathized with a major egg company that took the initiative to have its clear plastic egg cartons made out of more expensive bottle-grade PET in a bid to make them recyclable, but as Baldry says, "The problem is there are (clear) egg cartons out there that aren't made from PETE at all."

Recycling is a young industry. For sure, the plastics sector is struggling to make products recyclable and protect its flank against competing products, such as bio-plastics, that could add more challenges to recycling.

According to Par-Pak, using post-consumer PET reduces green house gas emissions to a 10th of what's required to produce virgin resin from fossil fuel, and the company wants to procure its recycled PET (both bottle and thermoform grades) from nearby sources.

"Our ultimate goal is to have our containers go into a blue box, collected, sorted and ground and us buy it and make more containers out of it.

"That's sustainable, and that is truly closing the loop," Armstrong says.

"Trash Talk" usually appears every Saturday in New in Homes & Condos *section of the* Toronto Star. *Send questions and comments to* *e_moorhouse@sympatico.ca*.

Pittsburg State Celebrates 40 Years of Plastics with Student Trip to NPE

Seventeen students and 4 professors traveled via Amtrak to Chicago to attend the largest plastics exposition in North America. Pittsburg State University is renowned for its strong commitment to training students in plastics processing. This year, several students reflected on their trip to McCormick Place.

To me NPE was a very educational experience that was informative and full of all kinds of new processes. Being able to see all of the machines running in that building was amazing and one of the most exciting experiences I have had as a student. Overall, I made a few good contacts while I was there so it was a very helpful event.

~ Cody McCarley

The NPE trip was informative, educational, and fun. It illustrated many different processes and machine types with skilled professionals from each company to elaborate on any questions or items of interest. It really allowed us all to see how vast the plastic industry is.

~ James Ismert

NPE was an experience. It gave me the opportunity to see what my industry has to offer and the incredible machinery that is out there. I went in there assuming I would see things that I was familiar with, but came out with a new perspective for the plastics industry. The industry is so vast, so it allows me to pick and choose the area I want to pursue after graduation, rather than being placed in an area.

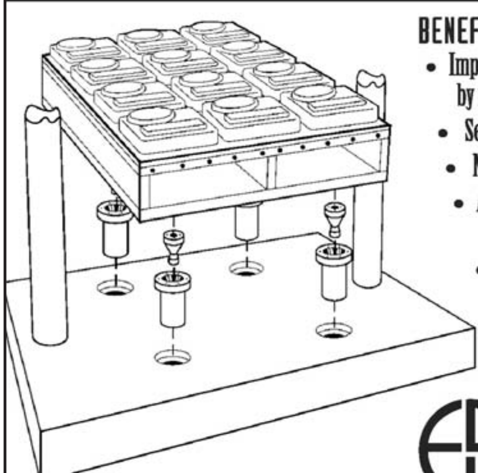
~ David Martin

NPE was one of the top highlight experiences of my college career. The showcase is mind boggling with the latest cutting edge technology on display. The demonstrations and networking opportunities at NPE have me excited to begin my career in the plastics industry.

~ Michael Thurman

The NPE/ANTEC trip was very inspirational. It gave all the students a chance to witness new technologies and meet new people. The trip was an experience that will not be soon forgotten.

~ Brad Tilman



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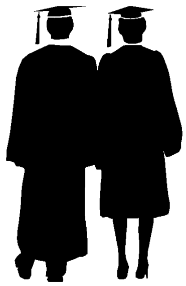

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Resin Life Cycle Estimation to Help Guide Sustainability Choices

Carol M. Casarino, Barry A. Morris, Susanne R. Veith
DuPont, Wilmington, DE

(Editor's Note: This paper was first presented at NPE 2009. It is reprinted here with the kind permission of SPI.)

Abstract

Life cycle analysis (LCA) is an accepted methodology to determine the environmental impact of a certain material or package at different stages in its product life. In some cases, however, LCAs can be complex and expensive to carry out. DuPont is looking at ways to internally estimate the LCA of its products by using a modular approach: building estimates of nonrenewable energy and green house gas emissions by summing proprietary information on our ingredients and unit operations. The output of this tool will be used to target our internal improvement efforts and potentially help our value chain partners make better multilayer flexible packaging design choices.

Introduction

As sustainability continues to gain prominence in the packaging industry, the industry is also becoming more sophisticated in understanding the nuances of what represents a truly sustainable product. Initially, the industry focused on such factors as biobased content and package weight reduction. While these factors are readily measured and communicated, they are not measures of actual environmental impact. As such, there is the possibility of a seemingly sustainable solution to have a negative environmental impact relative to the so-called nonsustainable incumbent.

The industry is now clearly moving toward measuring actual environmental impact. This is far more complex, but there is rapid progress. Indications of this progress include: the emergence of Life Cycle Analysis (LCA) as the premier methodology; standardization of the methodology; and the increase of LCA results which are publicly available. We are still a long way from being able to reliably measure the full environmental impact of packaged products, but these are strong foundations on which to build.

What Is An LCA?

An LCA is a detailed assessment of the environmental impact of a product or offering throughout its life cycle. Depending on the scope of the LCA, different environmental impacts can be considered.

Typically, LCA focuses on nonrenewable energy consumed and greenhouse gas (GHG) emitted. The nonrenewable energy consumed is net of any energy generated and recycled in the process and is reported as megajoules/unit, typically megajoules per kg of product (MJ/kg). The greenhouse gas emissions include emissions from utility generation (e.g., electricity, steam), as well as process emissions of any greenhouse gas, and are reported as kilograms of carbon dioxide equivalent/unit, again typically per kg of product (kg CO_2eq/kg).

A key part of performing an LCA is to scope it properly. Referring to Figure 1, a Cradle-to-Grave LCA would cover raw materials, manufacturing, use, and end-of-life phases. While it is certainly desirable to understand the environmental footprint all the way through the life cycle, the number of value chain participants makes it extremely difficult to obtain reliable data.

For this reason, most available LCA data is for so-called Cradle-to-Gate, which includes the environmental footprint of the production of raw materials and all required manufacturing steps. Although the scope of a Cradle-to-Gate LCA is certainly narrower than that of Cradle-to-Grave, it is still very much a challenge to get reliable and complete data sets so prudent assumptions and approximations are unavoidable in some cases. Also, comparing LCA results from different sources can be challenging since each study may make different assumptions on, for example, heat and electricity generation, which may result in slight differences of the final results. For these reasons, in general, we recommend to assume error bars on any Cradle-to-gate LCA result to be at least ±10% if the studies are not performed within the exact same scope.

For a resin supplier Cradle-to-Gate LCA, raw materials can include monomers, additives, process chemicals, etc. The resin manufacturer obtains data on the energy and GHG for each raw material -- this is often called the embodied or feedstock energy or embodied GHG. Embodied energy and GHG data can be obtained from a variety of sources -- public databases, LCA software packages, from the supplier, or depending on the degree of backward integration, from the resin manufacturer's own operations.

Again, from the resin supplier's perspective, manufacturing can include polymerization, pelletization, compounding, etc. Here the data can be internally generated -- typically looking at the energy consumed and greenhouse gas emitted over a given period of time, divided by the volume of product produced during that same time. Depending on the objectives of the LCA, this can be further broken down by unit operations, by product family, etc. Some of the manufacturing facilities may also produce multiple products, and the environmental footprint of the facility needs to be further allocated on different products. But recall that the error bars on LCAs is ±10%; therefore, a detailed breakdown may not yield meaningful distinctions.

DuPont's Role in Supplying LCA Data to the Industry

Key inputs to enable a packaging converter to conduct his own Cradle-to-Gate LCA is the embodied energy and GHG in the resins used to make packaging structures. As noted, there are a growing number of publically available databases providing data for a number of monomers, ingredients, and resins. Examples include PlasticsEurope, ACC, Ecoinvent, and other LCA software databases. These are generally based on industry averages and/or input from key industry players, and the results are aggregated to conceal any individual organization's proprietary information. As such, these data are generally available only for large volume commodity materials. Specialty resins, such as those supplied by DuPont, are smaller volume and often have only one or a few suppliers. For these reasons, specialty resins are not represented in these public databases.

DuPont recognizes its role in supplying this information about our products to support our value chain partners' efforts to reduce their footprint. We have done extensive LCA work in support of our renewable materials effort, and we are committed to providing only LCA results that have been obtained via the ISO 14040 series standards and have been validated by third party peer review.

DuPont's Approach

It is impractical to undertake a full-blown LCA on every one of our thousands of grades. So, in DuPont Packaging and Industrial Polymers, we are building a tool to help estimate the embodied energy and GHG in many of the key resins we supply to the packaging industry.

The tool must be flexible enough to address a wide range of the monomers and unit operations. Therefore, we have decided to use a modular design. A schematic of this is shown in Figure 2. We will have modules on each of our copolymer manufacturing sites (U.S., Belgium, Japan), as well as a selection of our compounding and reactive extrusion operations, based on our proprietary operations data. We will also have information on the environmental footprint of our monomers obtained from public and software databases or from in-house data. With this, a well-trained DuPont employee can plug in a proprietary composition along with the specific unit operations used in the manufacture and come out with an estimated footprint for that resin.

We believe that this initial design is a good balance -- focusing on where we can obtain reliable data and detailed enough to estimate environmental footprints within ±10%, but not so detailed as to be cumbersome. We recognize that this is a first step; for example, this initial design does not account for differences in rates or yields for different resin grades. If we determine those factors can have a significant impact on the results, we will further refine the model.

In implementation, we are as always following the ISO 14040 standardized method to ensure we are considering all the inputs and outputs impacting energy consumed and GHG emitted. Our plan is to have the overall tool and methodology to be third party peer reviewed; if successful, then we would be able to provide individual results externally without additional peer review. If not, our ability to share these results with our value chain partners will be limited.

How To Use LCA Data

We plan to use the LCA results from this tool for internal prioritization purposes. It could be used to identify areas where process improvement or new product development may have significant footprint reduction impact. Or looking at it another way, to raise a flag if a proposed change could have an unfavorable effect.

LCA can also help our converter customers drive package structure optimization by allowing comparisons between functional alternatives. For films, this will typically mean footprint per unit area that gives the same degree of product protection, shelf appeal, handling, abuse resistance, and other properties. While LCAs are typically computed in terms of energy requirements or emissions per unit weight, converting such information into meaningful functional alternatives is not always straightforward. One difficulty is that packaging structures can be put together in a myriad number of ways with a variety of converting processes. If we assume a comparable footprint in film converting, then we can compare the material quantities and footprint/kg of each material that makes up the packaging structure.

As an example, let us compare the use of three resins to make a clamshell structure: amorphous polyester

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(APET), high impact polystyrene (HIPS), and polylactic acid (PLA). Some of the characteristics of these resins are given in Table I. The traditional approach is to compare these materials based on cost and physical properties. The price and densities of these resins differ; however, on a unit volume basis, all three materials cost about the same. Because of its lower oxygen and moisture permeability, APET is favored for applications requiring moderate barrier. HIPS is favored for applications requiring breathability.

What about sustainability considerations? Table II lists the nonrenewable energy consumption and green house gas emissions for these materials. This information needs to be put on an equal basis for comparison. The high stiffness of PLA may allow it to be downgauged in this structure while maintaining the overall feel and function of the package. The bending stiffness of a film/sheet scales as the modulus times the thickness cubed. For comparison, we assume the APET sheet is 0.38 mm (15 mil) thick. We compute that the thickness of HIPS and PLA sheet needs to be 0.39 and 0.32 mm, respectively, to have the same bending stiffness as the APET sheet. We also must correct for the density of the resins. The combination of the density and thickness allows us to convert our footprint data from a per kg basis to the functional basis of per unit area. Table III shows the results of the calculations. We see that

- Using HIPS allows some reduction in energy and GHG emissions over APET because of its lower density.
- PLA gives the greatest reduction in energy and GHG emissions as a result of having an inherently lower footprint and the opportunity for downgauging. Downgauging may also allow for cost reduction.

In the above example, we have assumed the brittleness and use temperature limitations of PLA can be ignored. Our analysis highlights the potential of PLA if these problems can be mitigated through the use of additives or other solutions [3, 4].

For multilayer packaging films, the design considerations can be more difficult. There is a need to balance cost, stiffness or feel, sealability, strength, puncture and tear resistance, barrier, printability, and now sustainability. With multilayer structures, the calculations to obtain equal functionality can be less straightforward. Puncture and tear resistance are influenced by the adhesion between the layers as well as the properties of the individual layers. Bending stiffness is no longer a simple function of modulus and thickness; it becomes a function of the modulus, thickness, and relative position of each of the layers. As an example, consider a structure containing four layers each 25-μm thick. Two of the layers are made from a relatively stiff HDPE and two from a soft EVA or mPE plastomer. As shown in Figure 3, simply rearranging the layers so that the HDPE layers are on the outside increases the bending stiffness by up to a factor of 4.

DuPont has developed a multilayer cost and stiffness model [5] that allows us to look for ways to streamline structures through material selection and placement. An example is shown in Figure 4 for a processed meat web. Structure 1 is a (PA-tie-EVOH-tie-LDPE) structure with a total thickness of 108 μm. By putting a stiffer ionomer on the outside, the structure can be downgauged to 89 μm, an 18% reduction in thickness, while keeping the cost and stiffness constant. The next step is to incorporate the LCA analysis into this calculation to determine the net reduction in energy consumption and greenhouse gas emissions.

Conclusions

As the packaging industry becomes more sophisticated about quantifying sustainability, there is growing interest in measuring actual environmental impact through life cycle assessment. While data for large volume commodity materials may be available in public databases, this is not so for specialty resins. DuPont's approach to filling this gap is to develop a model for our manufacturing processes and compositions. The results should allow us to internally prioritize footprint reduction efforts. Where validated by third party peer review, these data can be used by our value chain partners to help assess footprint reduction opportunities in packaging structures.

References

1. PlasticsEurope Association of Plastics Manufacturers, 2005, http://www.lca.plasticseurope.org/main2.htm.
2. Vink, et al., *Polymer Degradation and Stability*, **80** (2003) 403-419.
3. B. A. Morris and D. Kirschbaum, "Modification of PLA for Improved Processing and Properties," Bioplastics Processing Conference, Charlotte, NC, Dec. 2007.
4. J. Uradnisheck, "Improved Dimensional Stability of Thermoformed Polylactic Acid Articles," 2009 SPE ANTEC Conference, June 2009.
5. B. A. Morris and J. D. Vansant, "The Influence of Sealant Modulus on the Bending Stiffness of Multilayer Films," presented at the 1998 SPE ANTEC Conference, May 1998.

Table I. Characteristics of Resins Used in Clamshell Example.

	Cost	Tensile Modulus	OPV	MVTR
Resin	\$/m^3	GPa	cc-25)m/m^2-d	g-25) m/m^2-d
APET	2500	2	45-90	15
HIPS	2300	1.8	4700-9300	155
PLA	2500	3.4	620	325

Table II. Environmental Footprint of Resins (Source: PlasticsEurope [1] and Vink [2].)

	Non-renewable Energy Consumption	Greenhouse Gas Emissions
Resin	[MJ / kg] (HHV)	[kg eq. CO2 / kg]
APET	80	3.3
HIPS	87	3.4
PLA	54	1.8

Table III. Calculation of Clamshell Structures of Equal Bending Stiffness.

	Density	Thickness	Weight per Area	Non-renewable Energy Consumption	Reduction	Greenhouse Gas Emissions	Reduction
Resin	g/cc	mm	kg/m^2	MJ / m^2	%	kg eq. CO2 / m^2	%
APET	1.35	0.38	0.51	41	0	1.7	0
HIPS	1.05	0.39	0.41	36	-12%	1.4	-17%
PLA	1.24	0.32	0.40	21	-48%	0.7	-58%

Figure 1. Life Cycle Schematic.

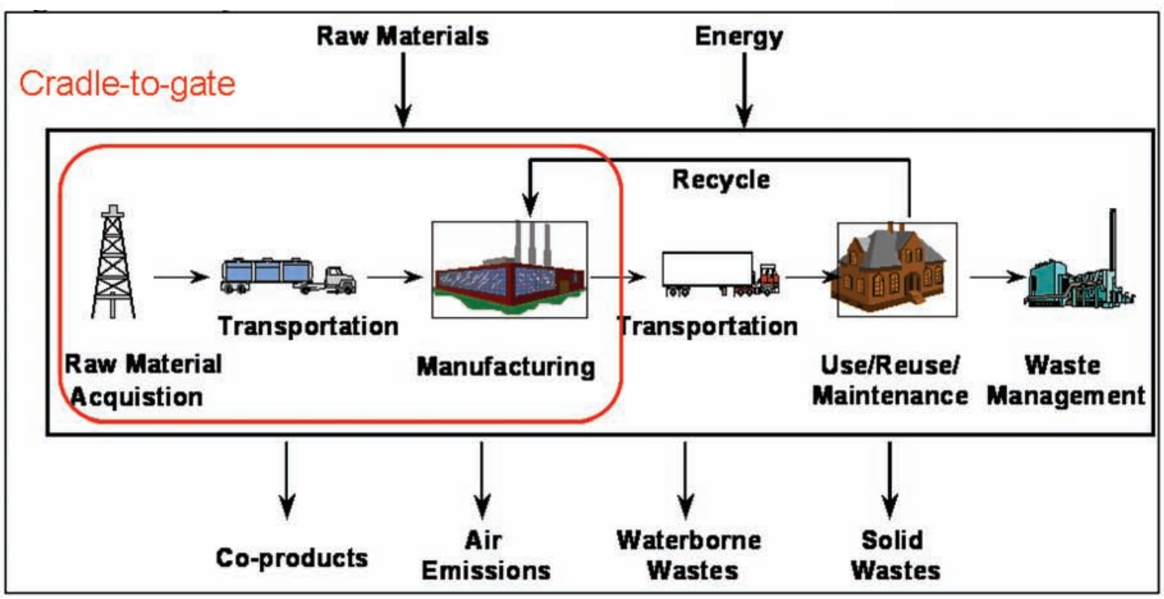

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Figure 2. Schematic of DuPont's Modular LCA Esimator Tool.

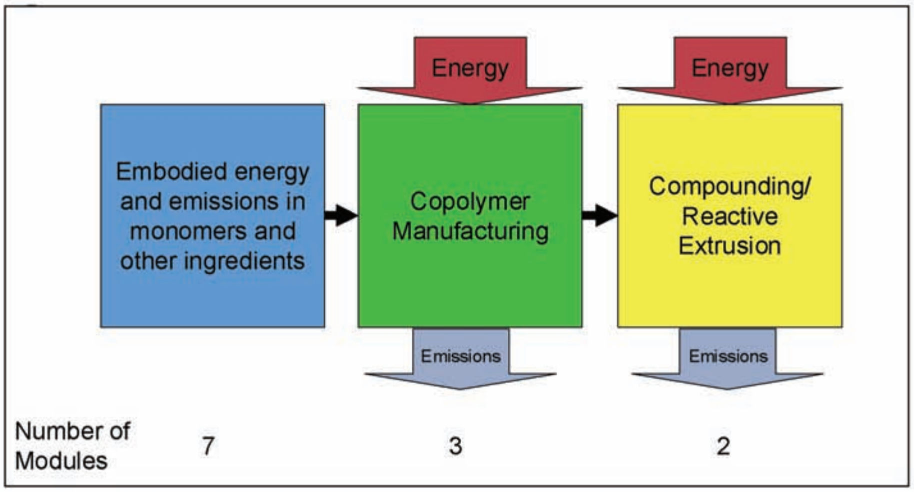


Figure 3. Example of How Layer Position Influences Bending Stiffness (Morris and Vansant, 1998).

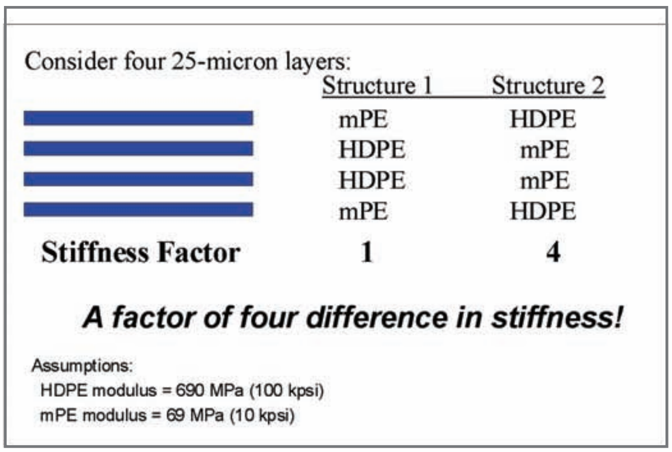
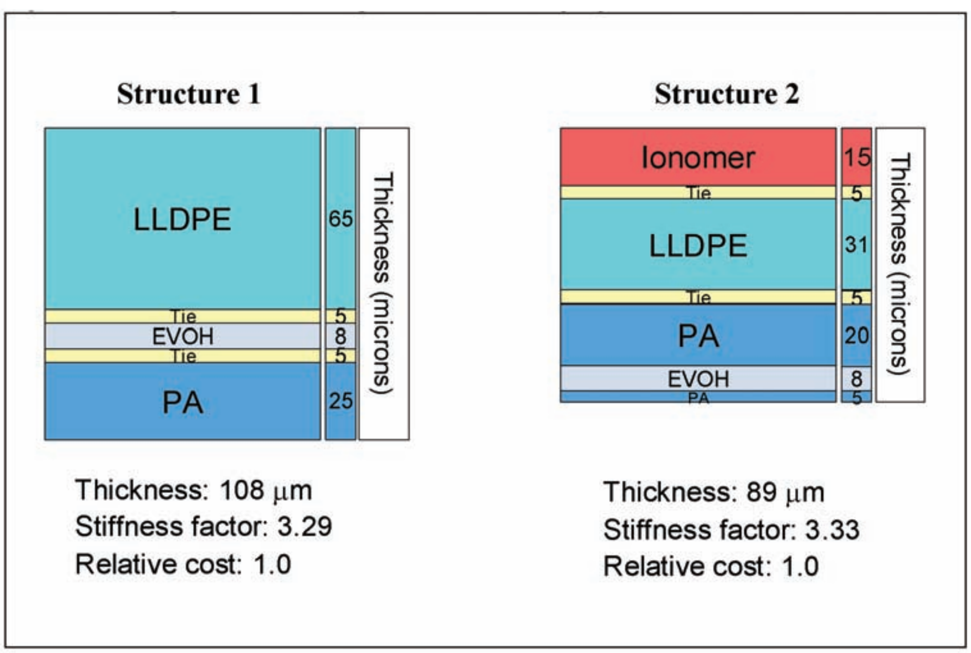


Figure 4. Example of Model Computations for Downgauging a Processed Meat Web.



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Solar Products
228 Wanaque Avenue
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(973) 248-9370
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msirotnak@solarproducts.com

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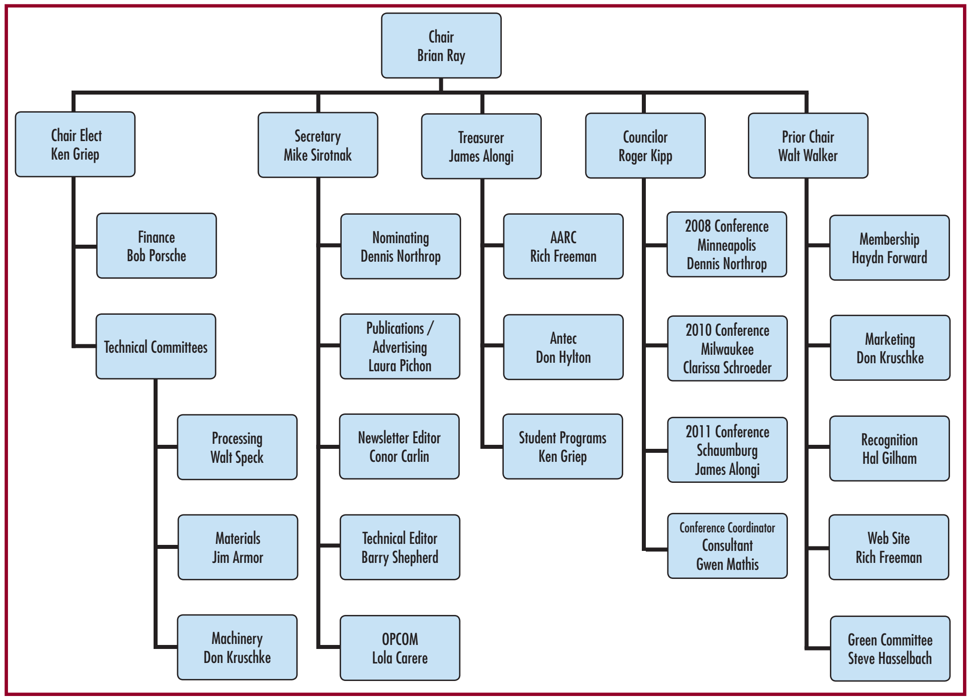

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