Improve Sustainability and Increase Profits in Polymers with Digitalization

By David Tremblay, Senior Director, Product Management, Aspen Technology, Inc.

aspentech | White Paper

Introduction

Plastics have changed the world, providing lightweight, durable alternatives to natural materials—often at much lower costs. As a society's standard of living increases, so does its plastic use. Manufacturers have found countless uses for plastics, from water bottles to car bumpers—but innovation in how to recycle those materials has lagged. While plastic consumption has grown threefold over the last two decades, only about 12% of plastic waste is recycled, with the rest making its way into landfills and oceans. [i] Concerns about managing this waste are growing, along with regulations and compliance mandates.

In January 2018, China, which had handled nearly half the world's recyclable waste for 25 years, banned the import of most plastics, leaving many governments scrambling to find new ways to manage plastic waste. [ii] Cities around the world have enacted bans on polystyrene food containers, plastic bags, straws and cutlery; there are higher expectations for polymer recycling to take place in the country of origin.

In response to this changing landscape, many companies are incorporating sustainability targets into their business goals, including safety, asset integrity, emissions management and waste reduction. As of January 2020, the Alliance to End Plastic Waste had secured commitments of $1 billion USD from 40 global companies, with a goal of $1.5 billion over the next 5 years. According to the organization's website, industry giants including Braskem, Dow, ExxonMobil, LyondellBasell, Reliance Industries Ltd., Sabic and Sinopec have joined the Alliance and publicly committed to reducing plastic waste and improving sustainability.

Technology offers polymer manufacturing companies opportunities to gain higher returns and drive new levels of optimization. Organizations who take advantage of these solutions position themselves to meet challenging sustainability goals while maintaining a profitable enterprise. Leveraging digital tools to develop new products and processes, reduce waste and optimize operations helps companies improve the bottom line.

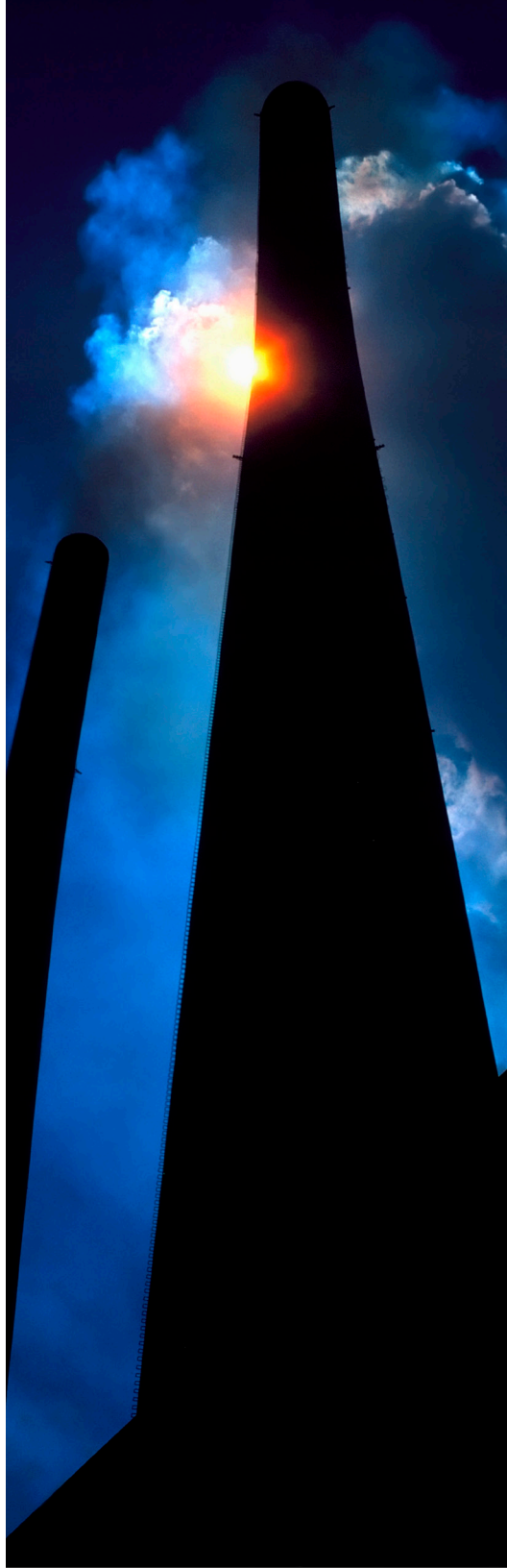
> "We must take a life-cycle view of our products and focus aggressively on designing products that are economically viable for recycling AND have the lowest environmental impact through their lifecycle. That must include incorporating carbon emissions into the equation."
>
> — Jim Fitterling, Chief Executive Officer, Dow
> Agenda for the 2020 World Economic Forum Annual Meeting [iii]

Building the Circular Economy

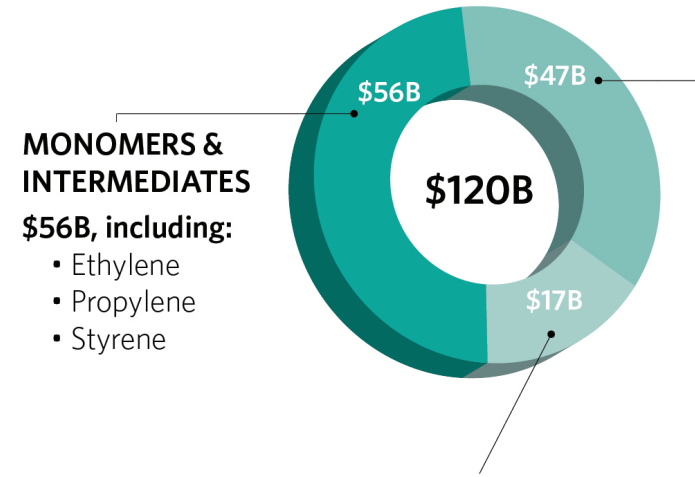
Today, there is a $120 billion USD market opportunity for polymer recycling in North America alone. [iv] In the past, most recycled plastics were reused to create less-valuable products—this so-called downcycling is not the most compelling use case for profit-minded polymer manufacturers. While processes like pyrolysis and gasification allow plants to convert plastics to fuel, they are high-energy processes that often produce harmful emissions. Process simulation tools enable companies to identify ways to minimize unwanted byproducts and reduce environmental impact.

In addition, chemical recycling offers new ways to break down plastics into their original components, eliminating downcycling and feeding a circular economy. With the right process simulation tools, plants can model these new recycling processes and study feasibility, while economic evaluation tools offer insight into whether a new process is profitable.

Researchers from the Department of Chemical and Petroleum Engineering at American University of Beirut and the School of Chemical and Biomolecular Engineering at The University of Sydney used Aspen Plus® to model pyrolysis of waste tires. They reported that the simulation model can "serve as a robust tool to respond to market conditions that dictate fuel demand and prices while at the same time identifying optimum process conditions (e.g. temperature) driven by process economics." [v] Companies can use the model to optimize the plant depending on the relative market demand for gasoline, diesel and other hydrocarbons.



COMBINED ADDRESSABLE MARKET



MONOMERS & INTERMEDIATES

$56B, including:

- Ethylene
- Propylene
- Styrene

POLYMERS

$47B, including:

- Polyethylene
- PET
- Polystyrene

REFINED HYDROCARBONS, PETROCHEMICALS & FULES

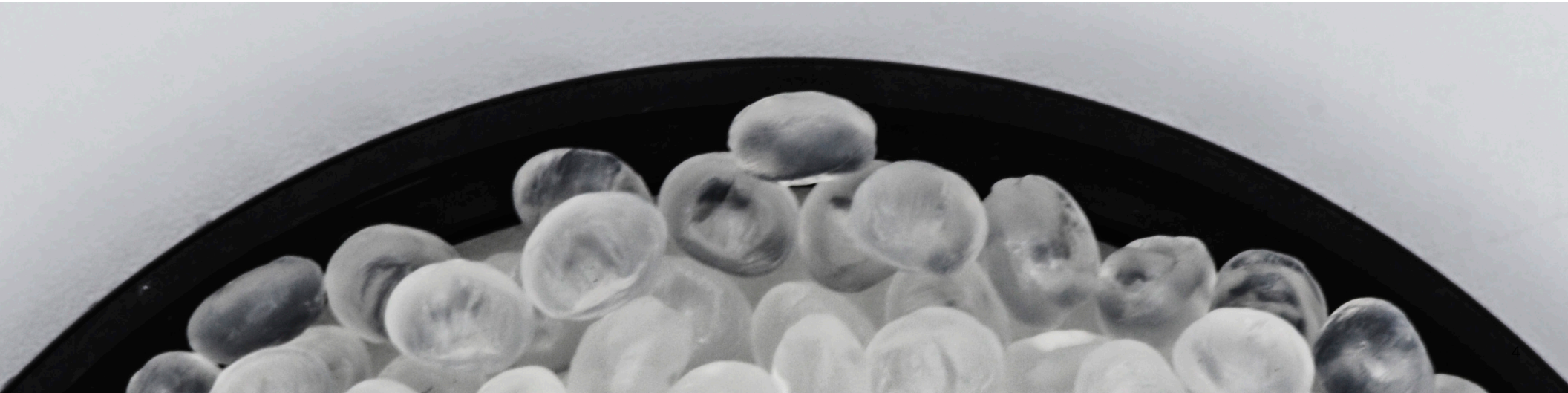
$17B, including:

- Naphtha
- Ethane
- Propane

Responding Quickly—and Profitably—to Customer Demands

Companies like Coca-Cola, Unilever and PepsiCo have announced commitments to incorporate recycled material into their packaging (while maintaining performance, of course) and plastics producers must accommodate these demands. [vi] Many polymer producers are well-versed in responding to customer requests for new products; the same tools that have helped create custom products in the past apply in this scenario as well.

Qenos was able to supply custom-tailored products to the market faster than the competition, using Aspen Polymers™ and data from the plant historian to optimize high-density polyethylene (HDPE) processes to meet customized specifications. Qenos reduced side reactions in the batch processes that produce off-spec material and completed plant trials for a new product grade 6 months ahead of schedule, saving $135,000 USD per year.



James Smith, a polymerization contact engineer at Qenos, explained, "One of the great advantages of modeling batch processes is that we get an understanding of what is happening as the reactants are consumed and as the polymer is changing over time. If you do not have a model to tell you what is happening, you are relying on trial and error and experience to determine the batch recipe. We cannot afford to operate this way."

Dow was able to speed time to market and reduce batch cycle time by 25% using Aspen Polymers and Aspen Plus® Dynamics to adjust process conditions. Examining insights from the model, engineers learned that a relationship exists between a polymer's application properties and its chemical structure—mapping the application properties to the structure allows the company to quickly respond to customer requests. Once Dow understands which application property a customer wants, staff can see which polymer structure is required and how to best design the process to consistently deliver the right structure. Ultimately, Dow reduced the overall time-to-market for new products.

Reducing Waste and Designing More Efficient Processes

Polymers producers can reduce waste in several different ways, all of which help improve margins. For example, in the previous examples where companies reduced time to market through process simulation, they were able to run fewer plant trials, thereby cutting costs and lessening the amount of off-spec product produced. SCG Chemical saved over $300,000 USD by eliminating plant trials for new HDPE grades.

Organizations can also save at the plant and process design stage, developing plants that use energy more efficiently. SCG Chemical saw over $1 million USD in capital savings in designing a new HDPE plant with a 400K tonnes per hour (TPH) capacity. In addition, the company was able to debottleneck existing plants using the same model.

Design changes that improve product quality reduce waste as well. Hanwha Chemical lacked insight into a low-density polyethylene (LDPE) process. Facing low production rates, suboptimal product quality and difficulty making operations decisions in the plant, Hanwha turned to Aspen Plus and Aspen Polymers to model the LDPE tubular reactor process to predict temperature profiles and polymer properties. With insight from the model, engineers could identify inherently safe operating conditions to increase production 5-7% per year while improving product quality and consistency.

Depolymerization:

This process allows companies to break down polymers including polyester, nylon and polystyrene into valuable monomers, which in turn can be used to produce new polymers. Typically run as a batch process, improper operation of recovery reactors can lead to poor yield or contamination that destroys the value of the recycled monomers. Plants must maintain optimal conditions to ensure they produce viable products ready for demanding applications. Batch process simulation provides a scientific basis to optimize batch recipe and operating procedures to minimize operating costs while maximizing yield and product quality. Multivariate analytics enables plants to monitor complex processes and make real-time adjustments to keep batch processes on target to improve consistency and yield between batches.

Creating More Eco-friendly Polymers

Many producers are focusing on developing green polymers based on sustainable fermentation products such as lactic acid and butanediol which can be derived from agricultural byproducts. Many new products are inherently more biodegradable than traditional synthetic polymers, reducing the accumulation of microplastics in the biosphere. Though biodegradable plastics currently only make up 5% of the market, this segment is projected to reach $6 billion USD by 2026, growing more than 20% over the next 6 years. [vii, viii] Biodegradable plastics currently have applications in packaging, textiles, consumer goods and agriculture.

Streamlining Operations Through Strategic Scheduling

While supply chain scheduling technology may not immediately come to mind as a tool that can help reduce material waste, it can do so in two different ways. Drawing on data, supply chain scheduling tools can streamline the order in which certain processes occur, reducing the amount of transitional waste between different product batches and cutting the energy output required to transition between processes. Scheduling technologies can help order individual production processes for each polymer batch based on which processes require similar conditions, reducing the number of dramatic changes between transitions, which typically require more energy. Optimizing the product wheel sequence and the grade transition procedures can improve operating agility and save companies millions by minimizing generation of off-spec product.

Using Proven Technology for New Purposes

Current projections anticipate new demand for recycled plastics of 5 to 7.5 million metric tons by 2030—and supply is stuck at just 6% of the current demand. [ix] Many companies that initially resisted using recycled materials are reconsidering as recycling becomes more economical and the demand for recycled good increases. According to a study by Closed Loop Partners, "using recycled plastics has benefits in many applications: it can be cheaper than prime plastics; pricing is less volatile than prime; and using it does not depend on new extraction of non-renewable fossil fuel resources." [x]

The industry is at an inflection point: while many companies put plastics recycling on the back burner, due to costs and the complexity of sorting waste, maintaining the status quo is no longer feasible. Polymer makers that are ready to adapt to the changing market can draw on the power of the same digital solutions that have helped them streamline product development and optimize operations in order to improve sustainability.

References

i **"The Plastics Paradox."** *The Long & Short of It*, Goldman Sachs, October 15, 2019.

ii **"Piling Up: How China's Ban on Importing Waste Has Stalled Global Recycling."** Cheryl Katz, Yale Environment 360, March 7, 2019.

iii **"Our Indispensable Problem: The Paradox of Modern Plastics."** Jim Fitterling, World Economic Forum, January 15, 2020.

iv **"Accelerating Circular Supply Chains for Plastics: A Landscape of Transformational Technologies that Stop Plastic Waste, Keep Materials in Play and GrowMarkets."** Closed Loop Partners, April 2019.

v "Pyrolysis of waste tires: A modeling and parameter estimation study using Aspen Plus®." Hamza Y. Ismail, Ali Abbas, Fouad Azizi and Joseph Zeaiter. *Waste Management*, Vol 60. February 2017.

vi **"Plastic Has a Problem; Is Chemistry the Solution?"** Alexander Tullo, *Chemical & Engineering News*, October 6, 2019.

vii **"Could Next-Gen Biodegradable Polymers Help Solve the Plastic Problem?"** Theresa Pultarova, *Engineering & Technology*, March 13, 2019.

viii **"Biodegradable Plastic Market by Type and Application: Global Opportunity Analysis and Industry Forecast, 2019-2026."** Research and Markets, 2019.

ix "Data and Analysis for Polymer Flow in North America." IHS Markit, 2019.

x **"Accelerating Circular Supply Chains for Plastics: A Landscape of Transformational Technologies that Stop Plastic Waste, Keep Materials in Play and Grow Markets."** Closed Loop Partners, April 2019.

aspentech | Technology That Loves Complexity

About Aspen Technology

Aspen Technology (AspenTech) is a leading software supplier for optimizing asset performance. Our products thrive in complex, industrial environments where it is critical to optimize the asset design, operation and maintenance lifecycle. AspenTech uniquely combines decades of process modeling expertise with machine learning. Our purpose-built software platform automates knowledge work and builds sustainable competitive advantage by delivering high returns over the entire asset lifecycle. As a result, companies in capital-intensive industries can maximize uptime and push the limits of performance, running their assets safer, greener, longer and faster. Visit **AspenTech.com** to find out more.

© 2020 Aspen Technology, Inc. AspenTech®, Aspen®, aspenONE®, the Aspen leaf logo, the aspenONE logo and OPTIMIZE are trademarks of Aspen Technology, Inc. All rights reserved. AT-05523