5-2015

Molding: A Summary of the Literature

Merissa Piazza
Cleveland State University, m.c.piazza83@csuohio.edu

Serena Alexander

Maxine Goodman Levin
College of Urban Affairs
Center for Economic Development

Prepared for:
Ohio Manufacturing Institute

MOLDING: A SUMMARY OF THE LITERATURE

Prepared by:
Merissa C. Piazza
Serena E. Alexander

May 2015

CENTER FOR ECONOMIC DEVELOPMENT

2121 Euclid Avenue Cleveland, Ohio 44115
http://urban.csuohio.edu

This Page Intentionally Left Blank

TABLE OF CONTENTS

INTRODUCTION

The Center for Economic Development at the Levin College of Urban Affairs at Cleveland State University prepared this report for the Ohio Manufacturing Institute (OMI) at The Ohio State University. The objective of this study is to provide background analysis of the plastic and polymer molding industry for the OMI as they prepare a roadmap for the future and recommendations concerning this industry for the Ohio Development Services Agency (ODSA).[1] This report provides a literature review and summary of findings.

Literature was collected and reviewed from various sources on the plastic and polymer molding industry. Academic articles, reports, and studies were collated and analyzed from databases, internet searches, and publications. The goal of this report is to provide a clear context of the state, national, and international conversation on the molding industry, as well as to delineate opportunities and challenges as it related to this technology. The focus of this report is on the plastic and polymer molding industry as well as its supply chain (both forwards and backwards).

DEFINITION

There are five types of plastic molding techniques: [2]

1. **Blow Molding** – This type of molding occurs when a piece of polymer, most often tubing, is placed in a mold with one end pinched off. Air is forced into the mold and the part conforms to the mold. Blow molding is ideal for hollow parts such as water bottles.[3]
2. **Compression Molding** - This type of molding occurs when a preheated polymer is placed into an open, heated mold cavity, which is then closed. Pressure is applied to the mold until the polymer has cured.[4]
3. **Extrusion Molding** - This type of molding occurs when thermoplastic pellets are stored in a hopper before being delivered to a heated barrel and forced through it. This results in long continuous pieces that can be cut to any desired length.[5]
4. **Injection Molding –** This type of molding involves a process of shaping plastic by melting it and injecting it into a predesigned mold.[6]
5. **Rotational Molding (Rotomolding) –** This type of molding involves a process where plastic is placed in a mold that is rotated at low speeds while being heated so that the plastic forms to the mold.[7]

[1] This report was prepared with financial support from the State of Ohio. All contents of this report reflect the views of the Grantee and do not reflect the views of ODSA or that of the State of Ohio.

[2] Hynes, P. (2013, December 18). Plastic Injection Molding 101 – Types of Plastic Molding. The Rodon Group. Retrieved on April 20, 2015 from http://info.rodongroup.com/blog/bid/96478/Plastic-Injection-Molding-101-Types-of-plastic-molding

[3] (n.d.) Blow Molding. Retrieved on April 20, 2015 from http://bmsplastics.com/molding-capabilities

[4] (n.d.) The Compression Moulding Process. Retrieved on April 20, 2015 from http://www.plasticmoulding.ca/techniques/compression_moulding.htm

[5] (2012, December 14). Extrusion Molding vs. Rotational Molding. Hedstrom Plastics. Retrieved on April 20, 2015 from http://www.hedstromplastics.com/blog/2012/12/14/extrusion-molding-vs-rotational-molding

[6] (n.d) What is Injection Molding? WiseGeek. Retrieved on April 27, 2015 from http://www.wisegeek.org/what-is-injection-molding.htm

[7] (n.d.) About Rotational Moulding. Association of Rotational Moulders of Australasia. Retrieved on April 27, 2015 from http://www.rotationalmoulding.com/rotomoulding/

STATE OF THE INDUSTRY

Global trends of the molding industry seem to focus solely on projections of the injection molding industry. It has been estimated that the global market in 2010 for the injected molded plastic industry was $168 billion and will grow to $252 billion by 2018.[8] According to Transparency Market Research, "Asia Pacific was the largest market for injection molded plastics in 2011, sharing 37.2% of the market followed by North America and Europe."[9] This dominance by Asia continued into 2013.[10]

There is a sizeable amount of literature in the trade press about the state of the molding industry as a supplier to larger industries that control delivery and pricing schedules. Moreover, insiders believe that the industry has turned the corner from the recession, and is producing at almost pre-recession levels.[11] The trade publication *Mold Making Technology* succinctly states, "With manufacturers putting increased pressure on their suppliers for cost savings and efficiencies, mold manufacturers are being challenged to produce consistent, accurate product cost."[12] This statement applies not only to the mold manufacturing industry, but to plastic molding as well. As manufacturers are placed in the tight spot of having a downward pressure from industry to keep costs low and an upward pressure from suppliers with the increased costs of raw materials there is little room for error.

Along with these pressures, there is a movement to increase efficiency in the production of molds and materials. Some examples of innovation that can enhance productivity and cost savings are the use of infrared photography to analyze the surface temperature of a mold or a molded part in order to find failure spots,[13] adjusting processes to increase productivity of advanced materials,[14] and investing in collaborative design systems and data management where mold design and manufacturing process occur concurrently.[15, 16]

[8] PRNewswire. (2012, October 8). Global Injection Molded Plastics Market is Expected to Reach USD 252 billion in 2018: Transparency Market Research. Retrieved April 2, 2015 from http://www.prnewswire.com/news-releases/global-injection-molded-plastics-market-is-expected-to-reach-usd-252-billion-in-2018-transparency-market-research-173089431.html

[9] Ibid.

[10] Grand View Research. (2014, May) Injection Molded Plastics Market (Polypropylene, ABS, HDPE, Polystyrene) Analysis By Application (Packaging, Consumables and Electronics, Automotive, Building and Construction) And Segment Forecasts To 2020. Retrieved April 2, 2015 from http://www.grandviewresearch.com/industry-analysis/injection-molded-plastics-market

[11] (2014, September) Changes, Chances & Challenges. *Canadian Plastics*. 20-23

[12] Driscoll, J. (2014, September). Costing Challenges and Strategies. *Mold Making Technology*. 23-25.

[13] (2011, March) Taking the Temperature of Mold Productivity. *Plastics Technology*. 30-41

[14] Henz, J. (2013, June). What's Different About Molding Engineering Plastics. *Plastics Technology*. 17-35.

[15] Jong, W.R., Wu, C.H., Liu, H.H., & Li, M.Y. (2009). A Collaborative Navigation System for Concurrent Mold Deisgn. International Journal of Manufacturing Technology. 40, 215-225

16 Low, M.L.H., & Lee, K.S. (2008). Mould Data Management in Plastic Injection Mould Industries. International Journal of Production Research,46 (22), 6269-6304.

ENERGY EFFICIENCY

Energy efficiency is a significant topic of conversation within the molding and polymer industries, and represents both an opportunity and a challenge. It represents an opportunity because energy efficiency is an essential component of cost savings in production and the savings associated with the lightweighting of these products. Lightweighting is a concept where lighter materials (i.e. aluminum, polymers, etc.) are substituted for standard steel products.[17] However, it represents a challenge because although the industry would like to pursue energy cost savings measures, the necessary technology may not exist to do so.

OPPORTUNITIES

Within the automotive, chemical, plastic, and molding industries, the topic of energy efficiency is extremely important since energy and fuel costs are reducing profits. Recently, the costs of fuel has dropped allowing for a reprieve for these manufactures, but as finite fuel resources are depleted small and medium-sized manufacturers will always seek a balance between operating expenses and profitability.[18]

The U.S. Department of Energy (DoE) has focused on energy efficiency in plastics manufacturing plants and has found that energy efficiency can take many forms including plastic recycling,[19] equipment improvement, and reducing the change-over time of equipment changeover.[20] The DoE engaged 11 companies through its Industrial Assessment Centers housed in universities across the nation and provided in-plant assessments on how these businesses could reduce costs through energy efficiency.

CHALLENGE

The chemical industry, a major supply chain industry for the polymers used in the molding process, plans to embrace energy efficiency as a part of its future. The International Energy Agency (IEA) commissioned a technology roadmap on energy and greenhouse gas reductions in the chemical industry. The roadmap found that in order for the chemical industry to obtain a change in the industry's energy consumption, "game changer" technologies will need to be created (i.e. biomass, hydrogen from renewable energy sources).[21] The IEA suggests that academia, industry, and collaborations between the two are need to foster R&D in the long-term to overcome these technology burdens.

Besides energy efficiency, the recycling of polymers is another challenge facing the industry. Many types of composites, such as carbon fiber and polymer composites, are difficult to recycle and are expensive.[22]

[17] The National Institute of Standards and Technology (2015, March 27) The NIST Center for Automotive Lightweighting Mission. Retrieved on April 23, 2015 from http://www.nist.gov/lightweighting/

[18] Society of the Plastics Industry. (2005). Improving Energy Efficiency at U.S. Plastics Manufacturing Plants. U.S. Department of Energy.

[19] SBIR Success Stories. (n.d.) High-Speed Plastic Recycling

[20] Ibid.

[21] International Energy Agency. (2013). Technology Roadmap Energy and GHG Reductions in the Chemical Industry via Catalytic Processes.

[22] U.S. DRIVE (2013, March). Materials Technical Team Roadmap. Driving Research and Innovation for Vehicle Efficiency and Energy Sustainability

NATIONAL CONVERSATION

There is a significant amount of national conversation in the molding industry as to the future of the industry; leadership in research and development most often comes from private industry. Government, academia, and nonprofits are seen solely as technology partners or funders. The U.S. federal government provides significant funding of basic science research in the polymer and molding industry via the National Science Foundation and Small Business Innovation Research Grants. Due to the nature of the inputs and processes of the polymer and molding industry, it is a heavily regulated industry. The U.S. Environmental Protection Agency (EPA) plays a regulatory role, and helps companies with technical assistance. Some major conversations topics in the industry include reshoring of workers, lightweighting of vehicles, medical technologies, and micro-molding.

RESHORING

There is significant conversation within the industry about plastic and polymer companies bringing manufacturing back to the United States or reshoring.[23,24,25] Plante Moran surveyed 84 businesses in the plastics industry on company performance and reshoring and found that reshoring continues to be a trend in the industry.[26] The reasoning behind reshoring includes lower energy costs in the United States and supply-chain logistics (i.e. such as the longer leads times for ordering parts, transit issues, and customs complications).

AUTOMOTIVE LIGHTWEIGHTING

In 1975, the U.S. government established the Corporate Average Fuel Economy (CAFE) standards, which sought to reduce energy consumption by increasing the fuel economy of cars and trucks.[27] The CAFE standards ushered in an era of greater fuel efficiency in cars. The Environmental Protection Agency (EPA) and National Highway Transportation Safety Administration (NHTSA) issued new standards through 2025 for cars and light trucks that would slowly ratchet the fuel economy of cars from 35.5 MPG in 2016 to 54.5 MPG by 2025.[28]

In order to comply with this legislation, automakers looked for several ways to increase fuel efficiency, one of which was lightweighting vehicles. As mentioned earlier, lightweighting substitutes lighter materials for standard steel products.[29] It is estimated that the average vehicle will be 400 pounds lighter by 2025.[30] The conversation surrounding CAFE standards is important considering that polymer molding is a large segment of the automotive industry; more R&D is needed to overcome some of the technical hurdles that are foreseen in the industry.

---

[23] Plante Moran. (2013). North American Plastics Industry Study: 2013 Survey Report.
[24] Hoch, B. M. (2012, December) Practical Guidance for Companies and Their Executive Site Selectors Involved in the Plastics Industry. Trade & Industry Magazine.
[25] (2014, September). Changes, Chances, & Challenges. *Canadian Plastics*. 20-23.
[26] Plante Moran. (2013). North American Plastics Industry Study: 2013 Survey Report.
[27] National Highway Transportation Safety Administration (n.d.) CAFE - Fuel Economy. Retrieved on April 23, 2015 from http://www.nhtsa.gov/fuel-economy
[28] U.S. Environmental Protection Agency, "EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks," http://www.epa.gov/otaq/climate/documents/420f12051.pdf.
[29] The National Institute of Standards and Technology (2015, March 27) The NIST Center for Automotive Lightweighting Mission. Retrieved on April 23, 2015 from http://www.nist.gov/lightweighting/
[30] Agarwal, R. (2013, May 7). Technology advancements enabling vehicle lightweighting. *Aerospace, Metals Industries*

One of the only roadmaps in existence in the polymer industry is the American Chemistry Council's (ACC) technology roadmap for the automotive industry.[31] This roadmap sets forth a strategy for the segment of this industry through 2030. The ACC strategy looks to leverage the lightweighting that already exists with the opportunities presented by new parts and composites made using plastics and polymers. The ACC has key initiatives and actions it suggests should happen within materials development, and the implementation process, as well as:

- **Industry-Wide Demonstrations** - High-profile demonstrations of plastics and polymer composites in practice to promote innovation and adoption
- **Material Selection and Part Design** - Enable suppliers and original manufacturers (OEMs) to select the best polymer composites
- **Manufacturing and Assembly** – Improve materials, components, and systems of manufacturing and assembly
- **Continued Materials Development** – Improve and foster new materials
- **Supporting Initiatives** - Improve coordination across the supply chain and strengthen the workforce

Beyond the ACC roadmap, there is some literature on lightweighting and the need for more information in this sphere. A report from the Center for Automotive Research noted that a roadmap is needed not only for manufacturers, but also for suppliers.[32] In addition, data from NHSTA shows that reducing the weight of heavier vehicles is beneficial to safety, but reducing the weight of lighter vehicles may have adverse effects, implying the greater need for research in this field as well as roadmaps.[33]

MEDICAL

Medical Injection Molding (MIM) is a type of injection molding process that is heavily regulated. Beyond regulation of the medical device industry that takes place under the U.S. Food and Drug Administration (FDA), MIM is subject to ISO regulation. This industry segment is regulated by ISO 9001 and ISO-13485.[34]

MICRO-MOLDING

Over the years, there has been an increased demand in the market for micro-molding, although there is some confusion about exactly what it is. The increased interest has resulted in numerous articles in trade magazines—often using different definitions or requirements of micro-molding. Whereas micro-molding parts should typically weigh less than a gram, micro-molding involves more than merely producing small parts; it also involves measures of efficiency and precision. In other words, micro-molding is about efficiently producing large quantities of small parts with precision. Similarly, micro-molding is not about hardware only; rather, it is the combination of machinery with innovation, processing, expert tool-building, and often, years of experience.[35]

[31] (2014, March). Plastics and Polymer Composites for Automotive Markets Technology Roadmap. *American Chemistry Council*.
[32] Baron, J. (2013, April 16) Road to 2025: Challenges and Opportunities in Vehicle Lightweighting. *Center for Automotive Research*
[33] Tamm, J. (2013, April 16) Assessment of Vehicle Mass Reduction Feasibility, Cost and Safety Effects for CAFE Rulemaking. The National Highway Traffic Safety Administration
[34] Lessard, D. (2011, Summer) Medical Injection Molding: Is it the future for your molding operation? *Plastics Business*.
[35] What is Micro-molding? (2009). Retrieved April 15, 2015 from http://www.accu-mold.com/pdf/Accumold_Micro-Molding.pdf.

Demand for Micro-Molding

The demand for micro-molded parts is expected to increase in the future due to an overall trend in the market to reduce parts' weights, and thereby reducing the energy intensity of products. Below is a list of markets demanding micro-parts:

- Automotive: Micro switch, sensors, ABS-Systems
- Computer: Head of an ink-jet printer
- Telecommunication: Mobile phone, MID
- Connectors: Plug connectors
- Electronics: Micro parts on circuit boards
- Micro-equipment: Valve technology
- Medical technology: Hearing aids, implants, biodegradable items
- Sensors: Airbag sensors, sensor disk
- Micromechanics: Micro motors, rotors
- Micro-Optics: Telecommunications, medical diagnostics (endoscopic and minimally invasive) surgical tools and micro sensor applications
- Watches: Gear wheels, latches, micro transmissions
- Precise suppliers: Various parts
- Institutes, Universities: Material and/or technology research [36]

Benefits

Compared to conventional molding, micro-molding has several benefits: [37]

- The quality of micro-molded parts is much higher than conventionally molded parts.
- Micro-molding can yield up to 80% material savings, 66% of energy savings, while providing 350% faster injection.
- Micro-molding is designed for and thus is optimized for producing small parts; yet, it can be used for slightly larger scale objects that require demanding geometry and tight tolerances.
- A micro-molder typically has the potential to perform a variety of traditional injection-molding processes at the micro scale.
- A micro-molder has the ability to mold two different materials on the same part simultaneously.

[36] Micro-Moulding: Battenfeld Injection Molding. Retrieved April 20, 2015 from http://www.battenfeld.ru/fileadmin/templates/docs/imm/microsystem_presentation.pdf.
[37] Ibid.

INTERNATIONAL CONVERSATION

- The plastics industry suffered in Europe during the recession, as it did in the United States. However, since then, it has recovered consistently. The European sector employs roughly 167,000 employees.[38]
    - Portugal has a long tradition as a mold-making country, but this industry was hard hit during the Great Recession. The opportunities found within emerging markets have brought promise and life back to the country's industry. Currently, Portugal exports 90% of its production to 120 countries; the major market is the automotive industry. Many companies, however, are looking to diversify by expanding their product development to include the aerospace industry.[39]
- The Indian Plastics Association has asked its government for help to invest in new technology to facilitate growth in the industry. The trade organization All India Plastics Manufacturer's Association (AIPMA) asked the Indian government for $3.9 billion to build more plastic innovation centers around the country.[40]
- Malaysia produces more than 60% of the resins used in the manufacturing of plastics. China, Hong Kong, Singapore, Japan, and Indonesia are the major consumers of these resins. The supply and demand of jobs in the Malaysian plastics industry is worth noting. According to a report by the Malaysian government, only a small fraction of the jobs available in the plastics industry have been filled due to insufficient supply of skilled labor. As the plastics industry grows around the world, skilled workers are needed to meet this demand.[41]

STATE ROADMAPS AND CONVERSATIONS

In the United States, the manufacturing of plastics and rubber has received considerable attention in several states, not only because they employ large numbers of workers but also because they are considered a "growth driver" and "major supplier" for other high-tech manufacturing sectors.[42] States have not focused their efforts on molding as an industry, rather the materials that are used in molding and molded products.

States' efforts to strengthen their competitiveness in attracting or retaining plastics and rubber manufacturers have taken the following forms:

WORKFORCE TRAINING AND DEVELOPMENT

Customized workforce development programs have been offered by several states to strengthen the competitive advantage of plastics and polymers firms. One example of such programs is Georgia's "Quick Start" skills-based training program providing job-specific training for qualified new and expanding firms at no cost. While "Quick Start" provides training for a wide range of companies, dozens of plastics and rubber manufacturers have taken advantage of its job-specific technical training services

[38] PlasticsEurope (2012). Plastics – the Facts 2012 An analysis of European plastics production, demand and waste data for 2011.
[39] Stephen, M. (2014, September). Portugal's Mold Making Industry is on the Rise (Again). Canadian Plastics. 30-32.
[40] Singh, S. (2013, December 3). India's Plastics Industry Asks Government for Help. *Plastics News*.
[41] (2013). Occupational Analysis Plastics Industry. Department of Skills Development Ministry of Human Resources, Malaysia
[42] See for example, Plastics and rubber manufacturing: A growth driver for high-tech manufacturing sectors. (2015, February 10). Retrieved April 15, 2015, from http://selectgeorgia.com/publications/plastics.pdf.

in the past. The "Quick Start" training program is based on a needs analysis conducted by its staff on a newly locating or expanding company. Training is provided either at the company's facilities or at a state-supplied facility near the company's site, such as a technical college. Additionally, these technical colleges offer four certificate programs—injection molding, extrusion molding, blown firm molding, and thermoform molding—as well as a three-year diploma program in mold-making apprenticeship. Public and private four-year colleges and universities within the state of Georgia also provide higher education in plastics and rubber products-related disciplines. The most prominent university is Georgia Tech with engineering programs related to the plastics industry, such as polymer, textile and fiber engineering; chemical and bimolecular engineering; industrial and systems engineering; and material sciences. In addition, students enrolled in rubber and plastics programs along with other programs may be eligible for full tuition reimbursement through the state's HOPE program.[43]

Some states have also emphasized the importance of offering online training to meet today's demands. For example, the Workforce and Economic Development Network of Pennsylvania (WEDnetPA)[44] provides both basic and advanced skills training programs; these program were the first online advanced technology and business training in the nation.

Universities across the nation that are major producers of graduates with degrees in fields applicable to the plastics and rubber industries include Purdue University; University of Michigan—Ann Arbor; Pennsylvania State University; Georgia Tech University; Texas AM University; University of Akron; and University of Florida. Each of these academic institutions provides a robust pipeline of high-tech talent by producing more than 1,000 graduates each year who could potentially work in the plastics and rubber industry.[45]

PROMOTING R&D, FOSTERING INNOVATION AND TECHNOLOGY TRANSFER

R&D can strengthen the economic foundation of states and their regions. Moreover, R&D is vital for their long-term innovative capacity. With plastics, polymers, and rubber industries increasingly seeking new ways to gain market share through the introduction of qualitatively distinctive products (as opposed to focusing on reducing costs alone), state-level policy to promote R&D and foster technology transfer has become increasingly more important. Research universities, innovation centers, and university-sponsored economic development organizations across the country serve as means for the states to take cutting-edge technologies out of the laboratories and into manufacturing facilities. Whereas the majority of these research and innovation centers focus broadly on advanced manufacturing industries, some focus primarily on plastics, polymers, and rubber industries. For example, the Plastics Research and Education Center at Ball State University in Indiana provides innovative strategies and support for implementation of strategies to create an advantage for plastic companies in targeted regions.[46]

The University of Southern Mississippi School of Polymers and High Performance Materials also has a variety of programs and departments that work together to not only provide technical and professional

[43] Plastics and rubber manufacturing: A growth driver for high-tech manufacturing sectors. (2015, February 10). Retrieved April 15, 2015, from http://selectgeorgia.com/publications/plastics.pdf.
[44] http://www.wednetpa.com/
[45] Ibid.
[46] Resource guide: University research programs and centers. (n.d.). Retrieved from https://cms.bsu.edu/-/media/WWW/DepartmentalContent/BBC/PDFs/resource/07 research.pdf.

training and services to help the state meet its workforce needs, but also develop new products and processes through research and development activities.[47]

Whereas research funding for plastic and rubber products first comes from federal sources, states willing to lead or compete effectively in the industry have been more active in promoting and supporting related university programs and centers. The Polymers Center of Excellence in North Carolina, which provides technical assistance and education and develops emerging technologies for the industry sector, is an example of such a center. The current off-campus facility is a successor of a Polymers Extension program as a part of North Carolina State University Industrial Extension Service, which was created as a result of state legislator allocating funds for it.[48]

Other examples of efforts to foster innovation and technology transfers include the University of Pennsylvania's Knowledge Park (for developing plastics businesses), the Plastics Computer-Aided Engineering Center in Lowell, MA (for developing and deploying computer-aided engineering and design technologies), the Plastics Technology Center located on the Erie, PA, campus (to help plastic-related companies become more competitive through innovations in product and part design, process improvement, rapid prototyping and tooling, materials testing and analysis, and metal to plastic conversion), and the Plastics Manufacturing Center as a technology resource center in the Williamsport, PA, campus. [49]

In the state of Ohio, there are leading efforts to foster a polymer and plastics industry. PolymerOhio, an Edison Polymer Innovation Center and a NIST Manufacturing Extension Partnership located in Columbus, Ohio aids business growth, workforce, new product development, and market exploration for companies in Ohio in the molded or extruded plastic markets.[50] The University of Akron, known for its College of Polymer Science and Polymer Engineering has an Applied Polymer Research Center that works with up to 400 clients a year to test materials and aid businesses polymer related problems.[51]

Strengthening Networks, Creating Partnerships, & Providing Professional Support

Manufacturers can benefit greatly from plugging into a wide network of suppliers, customized workforce training entities, and establishments that generally help them increase top-line growth through innovation and reduce bottom-line costs. Through support by the state's leaders and communities, these networks and partnerships can be strengthened. Increasingly, states are trying to attract manufacturing firms by highlighting the strength and support of their existing infrastructure and partnerships between research and innovation centers as well as educators and training providers. The Georgia Manufacturing Extension Partnership (GaMEP) is an example of efforts to bridge the gap between university-based innovators and researchers and manufacturers. The GaMEP is part of the Georgia Tech Enterprise Innovation Institute and has nine regional offices across the state, offering a solution-based approach through coaching, implementation, and training in various areas including but not limited to sustainability and energy-related issues. In 2014 alone, GaMEP worked with more than

[47] Analysis of the Micro Economic Environment and Labor Needs for Development of the Plastics and Polymers Industry Cluster in Mississippi. (2002, March 1). Retrieved April 20, 2015, from http://www.taimerica.com/previous/polymer_study_final.pdf
[48] (n.d.). Retrieved April 22, 2015, from https://carpetrecovery.org/wp-content/uploads/2014/04/Polymer_Center_Excellence.pdf.
[49] Northwest Pennsylvania as a locale for the plastics industry. (2004, July 1). Retrieved April 16, 2015, from http://www.northwestpa.org/images/PDFs/Plastics.pdf.
[50] PolymerOhio (2014). History. Retrieved May 5, 2015 from http://polymerohio.org/polymerohio/history/
[51] University of Akron (2015). Applied Polymer Research Center. Retrieved on May 6, 2015 from http://www.uakron.edu/aprc/

1,700 manufacturers including plastics and rubber product manufacturers helping them reduce costs, increase sales, and create or retain jobs.[52]

Developing a Vision or Roadmap for the Future of the Plastics Industry

For those states in which the plastics and polymers industries are important players in the economy or manufacturing sector and which are leading employers, developing a vision and preparing a roadmap for the future of the industry is critical. For example, the Wisconsin Department of Administration has undertaken Wisconsin Industries of the Future (IOF), targeting economically critical industry sectors including the plastics industry. The program seeks to improve the state's competitiveness by increasing the use of energy-efficient and environmentally-sound technologies.

The "Industries of the Future Roadmap for the Wisconsin Plastics Industry" is the product of brainstorming sessions attended by plastics industry stakeholders (i.e. industry, public and private technology development, and state and federal industrial assistance representatives). The roadmap identifies three primary steps:

1) Recognize needs and create possible solutions for improving energy efficiency, environmental performance, and production efficiency in the Wisconsin plastics industry;
2) Strengthen both technical and financial partnerships between industry, government, and technology innovators seeking to implement projects;
3) Facilitate the pursuit of opportunities by identifying resources and making them accessible to implementers.[53]

Creating a Pro-Business Environment

To attract and/or retain plastics and polymers industries, state efforts have also taken the approach of creating a pro-business environment. For example, Pennsylvania's "Keystone Opportunity Zones" program aims at reducing the cost of business in certain areas of the state through credits, waivers, and comprehensive deductions, as well as total taxes on economic activity.[54] R&D tax credits are another form of reducing the cost of doing business while encouraging research and innovation. Incentive packages go beyond taxes and often include free training programs for basic or advanced skills as well as customized training programs tailoring the specific needs of plastics and rubber manufacturers.

Facilitating Exports by Investing in Infrastructure

Manufacturers realize that the best opportunity for growth, depending on their type of industry and products, might require that they export products to other countries, other states, and/or regions. Consequently, many states have put an emphasis on strengthening their export base beyond their current capacity. For many small and medium-sized manufacturers, it is necessary to clear several hurdles--including lack of capacity, internal market expertise, or limited access because of their outdated infrastructure or lack of technology—before they can embrace new opportunities. States can play an important role in helping manufacturers overcome these barriers. In addition to the states' role in supporting plastics and polymers manufacturers through the aforementioned strategies, investing in

[52] Plastics and rubber manufacturing: A growth driver for high-tech manufacturing sectors. (2015, February 10). Retrieved April 15, 2015, from http://selectgeorgia.com/publications/plastics.pdf.
[53] Industries of the future roadmap for the Wisconsin plastics industry. (2002, October 1). Retrieved April 16, 2015, from http://www.ecw.org/sites/default/files/plastics_roadmap.pdf
[54] Northwest Pennsylvania as a locale for the plastics industry. (2004, July 1). Retrieved April 16, 2015, from http://www.northwestpa.org/images/PDFs/Plastics.pdf.

infrastructure is crucial for facilitating exports. While the supporting infrastructure for strengthening the export base goes beyond transportation infrastructure, well-maintained water, air, rail and highway infrastructure ensures superior accessibility for moving products to markets faster and easier. Depending on the type of plastics products and distance to markets, different modes of transportation might be desirable. Thus, investment in transportation infrastructure should be made with careful analysis of industry and product makeup of regions and states.