Prodictivity and Energy Efficiency – Setting the trends for Injection Molding Machines

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Key Mesages

- Challenging injection molded products are increasingly being manufactured worldwide; high-quality European machines satisfy local market requirements and, open up further sales opportunities in North America and Asia.
- Four main trends: Energy efficiency, production efficiency, higher machine performance and contamination-free production.
- Injection molding machines have either electro-hydraulic, mechanical, or hydrostatic motion control. Or a combination of them.
- Co-operative working partnerships, high-performance components and a deep understanding of the molding process are decisive in the development of leading edge motion control solutions.

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Introduction

In autumn 2013, Moog surveyed manufacturers and users of plastic injection molding machines about developments in their industry. In this paper the most important results of the survey are discussed including the current requirements and needs of manufacturers and users of injection molding machines. First, the most important trends in the manufacturing of molded plastic parts were explored in economic as well as commercial contexts. From this background, the study extrapolated the effects that these trends are having on motion control technology. Injection molding encompasses a broad spectrum of applications for which there are machines of differing size, performance and repeatability. Correspondingly, in terms of motion control, there is no single leading technology which fulfills the various requirements to the same degree. Electromechanical, electro-hydraulic and electro-hydrostatic motion control technology exist alongside each other and each type has specific strengths for particular applications.

The End Product Market

In 2009, the European market processed a total of 10,990,000 metric tons of polymer through injection molding; the overwhelming part (47 %) was used solely by the packaging industry. [1] Further important sectors are the white goods (household appliances etc.) (13 %) and the cost-intensive and correspondingly high-value area of 'electronics/ telecommunications' (11 %) as well as 'automotive parts' (14 %). [1] Polymers were also injection molded for use in medical, pharmaceutical and optical products (7 %) and technical parts (8 %). [1]

The Injection Molding Machine Market

The injection molding machine market mirrors the situation in the end product market: In 2012 the machines sold world-wide in the greatest numbers were generic injection molding machines to be used primarily in the production of packaging and in white goods manufacturing.

In general, the market shows steady slow growth. A slightly higher growth is expected in sales of precision machines and high speed packaging machines. Precision machines are defined by short cycle times and repeatable functions; they are used predominantly for the production of technical parts, as well as in the 'electronics / telecommunications' and 'automotive parts' sectors. High speed packaging machines are very robust and work with a high injection performance, and are therefore seen for the most part in applications where thin wall packaging parts such as cups and containers are manufactured in large quantities.

The Markets

The largest market for injection molding machines is Asia. In 2012 this region saw a total of 66,000 injection molding machines sold, the greatest proportion of which were to China. [2] The demand in Europe is significantly smaller with 11,240 machines sold, followed by the Americas with 7,500 injection molding machines sold in 2012. [2]

While the demand in America was mainly satisfied by imports from Europe (1,900 machines) and above all from Asia (4,700 machines), the European and the Asian markets cover their own needs to a large extent by themselves. [2] The most important market for European injection molding machine manufacturers is therefore the European marketplace.

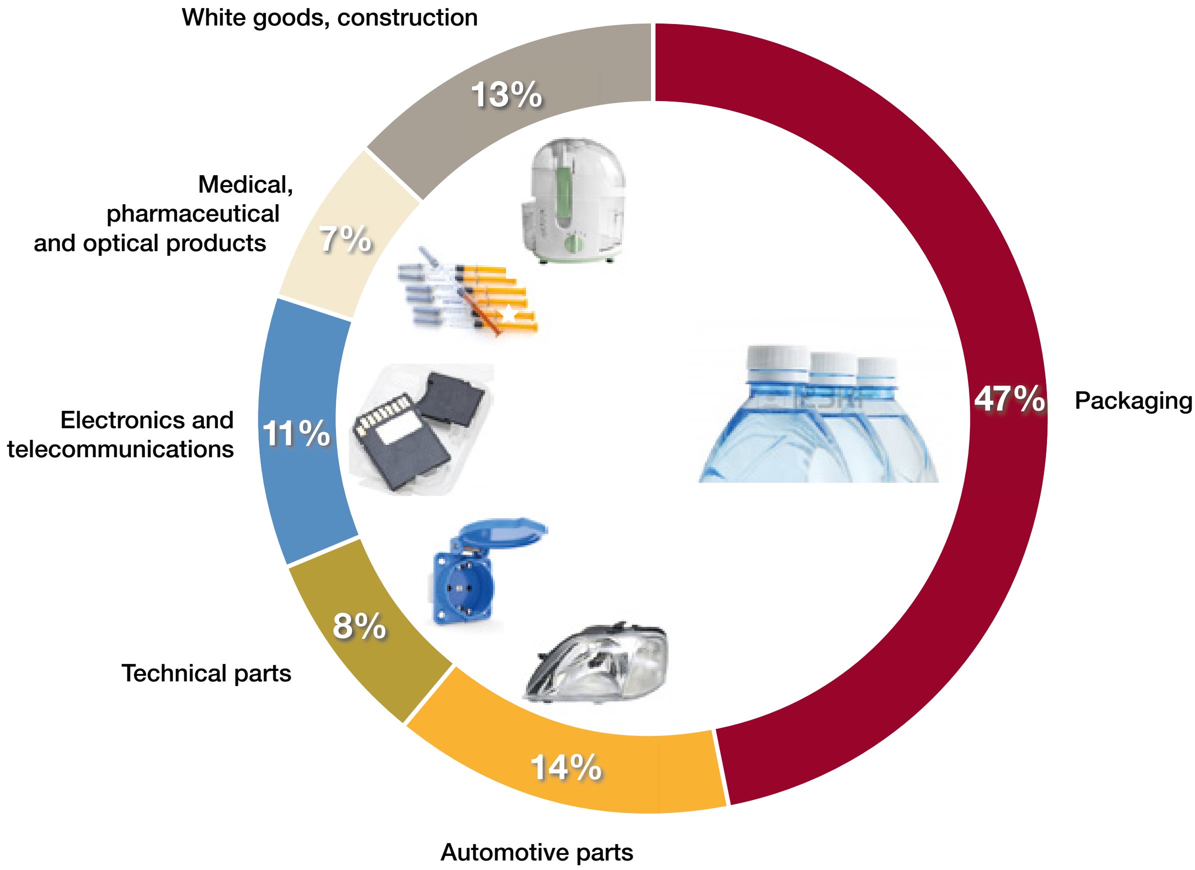

Fig. 1: Polymers processed in injection molding in Europe 2009 by end use markets (tot. 10,990,000 tons); Source: AMI report M118 /space March 2010 (Newly grouped by author)

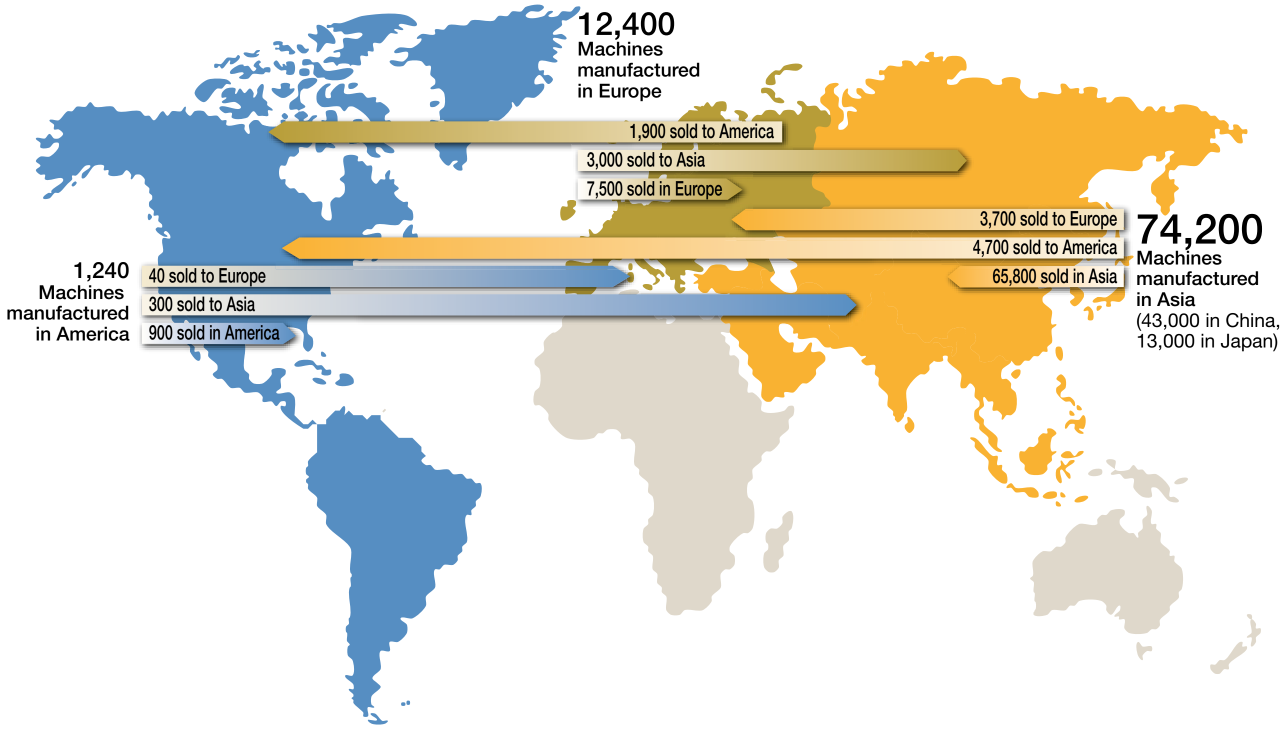

Fig. 2: Injection molding machines sold worldwide in 2012; Source: Engel, Plastics Today

Opportunities for European Manufacturers

The demand for higher quality machines is increasing. This applies to all markets. In Asia – and in particular in Japan, China and Southeast Asia – the demand for fast operating precision machines is growing at an above average rate. In North America demand is predominantly for fast, precision machines. The level of demand in America is rather small but steady. With an expectation of falling energy costs in North America based on an increased availability of domestically sourced fossil fuels, this may lead to new opportunities in this market. In Europe, demand is believed to remain stable; however, the demand for larger and higher performance machines could show positive effects.

European injection molding machine manufacturers serve the demands of their core market through the production of higher quality machines. This could open up additional opportunities for higher sales in North America, China and Southeast Asia. However, for the Asian market, it is yet to be seen how the competitive situation will develop as Chinese manufacturers move toward producing higher quality machines covering one particular demand of the Asian market (also known as "good-enough philosophy").

2 Overview of the Market Conditions and the Most Important Trends

For successful machine manufacturers, a deep knowledge of the requirements and needs of their customers is crucial of machine manufacturers. Therefore, we ask the following question to get a clear picture of their needs: What are the most important requirements and needs of the plastics industry at the present time?

We found that today the plastics processing industry is striving to continually reduce overall manufacturing costs. [3] To achieve this goal, plastics processors focus on four keys: Energy-savings, material savings, integration of additional production processes, and higher machine output achieved by greater cavity numbers or shorter cycle times. [3]

Alongside the need to reduce costs, the plastics processing industry has additional requirements of conforming to the specific demands of production conditions in the sectors of 'food packaging', 'cosmetics and hygiene products', and 'pharmaceutical products' [3]. In these sectors the end product cannot be contaminated by oil, dust and other pollutants. The aim here therefore is to have a manufacturing environment that fulfills the cleanliness demands of these products.

So what trends that can be derived from these needs and requirements? The plastics processing industry is targeting four key areas:

- energy efficiency
- production efficiency
- machine performance
- contamination-free manufacture of packaging for food, cosmetics and hygiene and pharmaceutical products.

3 Overall Social Context: Sustainability

At least two of the trends named above can be regarded as 'Megatrends' in the John Naisbitt* sense. They need to be considered in the context of the increasing scarcity of resources (e.g., fossil oil) and the general social discussion of sustainability. The core themes of this discourse are energy efficiency and the sustainable handling of non-renewable resources that must be addressed to secure long-term existence. It can be assumed that these trends will be long-term and will lead to far-reaching social and economic changes.

Ever since the Rio conference of 1992 and the Kyoto Protocol of 2005, sustainability has had political power behind it and will be increasingly implemented into international and national legislative systems – particularly in Europe. These new standards demand new ideas and processes in manufacturing.

Manufacturers of injection molding machines are likewise affected by these developments. A prime example is the eco-design guideline 2009/125/EG which was brought into law in Germany as the 'Energy-driven Product Law' (EBPG).

The eco-design guideline is not directly applicable to injection molding machine manufacturers because there are not 200,000 injection molding machines in circulation per year in the European Union. Nevertheless it does have an effect indirectly on machine manufacturers, because certain components such as electric motors come under the standard.

Furthermore, future operators of injection molding machines in the future will have to prove that they have a process in place that helps to continually improve their energy efficiency. Many companies operating injection molding machines are already endeavoring to produce this evidence today. An inducement for this is a partial refund of the EEG levy on electricity costs. In Germany, the tax cap has been granted since 2013 only to large companies that introduce an energy management system in accordance with DIN ISO 50001 by 2015, and smaller and mid-sized enterprises that carry out an energy audit in line with DIN EN 16247-1.

In plastics processing, the interviewees were in consensus, that raw materials costs make up most of the production costs of injection molded parts. Plastics processors can influence these costs primarily through an optimized design of the mold. Apart from this, raw material costs are driven by the commodity market. However the plastics processor can influence his direct production environment in two key ways. First the economical use of the raw materials may help significantly reduce production costs. Secondly, processors can seek to reduce the overalol lifetime cost of injection molding machines. Here it is energy costs, which make up the greatest part of the overall costs (see fig. 3).

Energy efficient and robust quality machines are certainly more expensive to purchase than regular machines, but they do reduce the operating costs. This leads to the higher

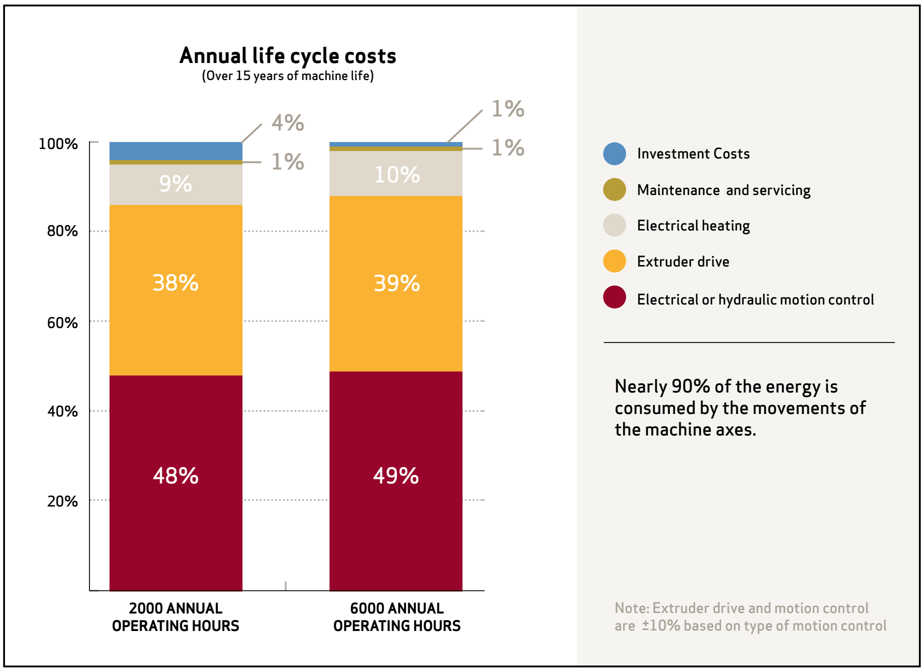

Fig. 3: In percentages, the overall lifetime costs of an injection molding machine, dependent on annual operating hours, (does not include cost of raw material for the injection molded parts); Conditions: 15 years machine lifetime, electricity costs of 0,0914 EUR/kWh, specific energy consumption of 0,93 kWh/kg of processed material (this average value is taken from a EUROMAP survey from 2011); Source: Bonten, Resources Efficiency with Plastics Technology, 2014, S. 60

investments being relatively quick to amortize, which is why at the bottom line they help significantly improve the bottom line. The acquisition of more energy-efficient and sustainable machines corresponds, therefore, not only to an overall societal trend, but also to a commercial rationale.

4 The Individual Trends in Focus

Energy Efficiency

Today, energy efficiency is the decisive criterion for all plastics processors when they buy a new machine. [3] It is expected that all electric machines will experience an upturn in sales, particularly as they promise energy savings of up to 50 % in comparison to hydraulic systems. [4] The question is, however: Is there no competition for fully electric systems at the present time?

Although the all-electric machine is becoming increasingly popular in the medium clamping force range from 100 to 600 tons, there are applications where this is not true. For example, when looking at machines with high cycle rates, hydraulic solutions are maintaining their position in this market segment. This is true in particular for the injection axes of high-speed packaging machines. At this point, there is no economical all-electric solution in sight that could fulfil the peak power demand. Furthermore, hydraulic systems based on servo pumps have reached a high degree of energy efficiency. As an example, this technology is dominating the segment of small machines up to 100 tons clamping force. In this market segment electric solutions are expensive, and, they are only competitive in niche applications such as molding precision micro-parts or medical applications. Also, for large machines with a clamping force of over 600 tons, hydraulic solutions remain dominant. All-electric solutions, due to a lack of standard machine components in this segment, can only be implemented at considerable cost. Currently, in this segment servo pump solutions and hydrostatic systems are more commercially viable – with high energy efficiency as well.

Today all-electric machines are considered most competitive in the mid-clamping force range of between 100 to 500 tons. Furthermore, hydraulics, servo pump and hydrostatic systems have also reached a high level of energy efficiency. Therefore, each plastics processor will carefully select specific and even customized machines to best fulfill his specific needs.

Production Efficiency

Production efficiency is a significant consideration for all plastics processors who produce large quantities of the same product (e.g., in the-'packaging'-and-automobile parts'-sectors). [3] Product design, the properties of the materials and the configuration of the molds form the basis for the efficient application of raw materials. In these market segments, high availability of the machinery is the key to productivity.

Production efficiency can be achieved in different ways. Should the efficient use of raw materials be the focus, then optimization of the weight of the molded part is particularly significant. This can be achieved through a reduction of the wall thickness of the molded part which then requires a shorter injection time and consequently also a higher injection speed. A further possibility in increasing production efficiency is the integration of downstream production steps into the process. To do this, a time-optimized ejection and a time-optimized transport of the product to the downstream production steps are required. Also, the integrated manufacture of complex products (e.g., containers with a lid and seal) contributes to more efficient production in that it saves downstream processes (known as multi-color machines). For this purpose, however, complex tools with additional injection units are required, which must then be integrated and synchronized within the machine cycle.

The spectrum of manufactured parts created by injection molding is very broad. A motion control solution tailored to the specific application makes a decisive contribution to production efficiency.

Machine Performance

High performance machines are also particularly of interest to plastics processors who mold the same parts in large quantities (e.g., in packaging). [3]

To increase the output, these processors are particularly interested in tools with as many mold cavities as possible. [3] For that purpose the machine will require high injection power, and, in order to be able to achieve the necessary repeatable accuracy – a highly dynamic control of the injection axis. Tools with a larger number of mold cavities are heavier than smaller tools and the dynamic performance demand for the clamping axis is increasing accordingly. The output of machines with high cycle rates does not only increase through higher injection performance. It can also be increased by the optimization of the product ejection and transport, which in turn reduces the cycle times.

In the case of precision machines, the machine's performance can be increased, for example, by increased accuracy and repeatability of the molding process and synchronizing ejection and transport of the molded parts.

A further possible means of increasing output can be achieved by specialized machines, which are part of an application-specific production line. These machines are typically optimized for a particular product (e.g., for PET preforms).

Increases in machine performance can therefore be achieved with all types of injection molding machines. Here too, the tailoring of machines to the specific requirements of a product segment, or to the specific needs of plastics processors, based on their production portfolio, is key to productivity.

'Clean' or Contamination-free Production

Contamination free production is very important to all plastics manufacturers that are active in the 'medical packaging'-, 'medical equipment'-, 'food packaging-'sectors. [3] From an economic standpoint, and due to regulatory standards – these machines must operate free of contamination and be easy to clean. All-electric systems are of core interest. Encased electromechanical actuators do not produce dust, and, liquid-cooled electric systems mean that surface temperatures remain low, thus minimizing thermal air flow. However, similar effects can also be achieved with other motion control solutions: Sealed electro-hydrostatic actuators reduce the risk of contamination through oil leaks or oil dust. The minimizing of thermal air flow is also possible in the case of highly efficient electro-hydrostatic machines. Fully electric systems are therefore on the march in this sector, but are not without competition.

5 The Moog Solution

Close Partnership and a Technology-neutral Approach

The broad spectrum of injection molding applications demands different types of injection molding machines, and there are various motion control technologies for each machine type. Depending on the size, the power and the repeatability required, electromechanical, electro-hydraulic, electro-hydrostatic or hybrid (a mix of hydraulic and electric) motion control solutions can be sourced. In addition, machine builders can use correspondingly offer the best economy. However, most motion control suppliers specialize only in one type of technology. This kind of limited offering carries disadvantages which can often force injection molding machine manufacturers into design compromises.

Therefore, many years ago, Moog adopted a technology-neutral approach which also drew on a profound know-how in respect of all types of motion control solutions. This is the only way that every motion control solution can be evaluated in order to fulfill the specific application requirements in the best possible way. Close partnership, high-performance components, a firm grasp of applications and long years of experience in the plastics processing market, form the basis for the development of a motion control solution best suited to carry out specific tasks.

The following brief examples illustrate this approach:

Example 1: For axes that have to produce high forces, electro-hydrostatic drives often offer the most economical solution. Even with injection molding machines with electromechanical main axes, an electro-hydrostatic drive could be the best choice for the secondary axes (e.g., ejectors, carriage). This solution is very robust and offers high efficiency (energy efficiency), good dynamics (production efficiency and machine performance) and cleanliness due to a sealed system, – advantages in all four trend areas.

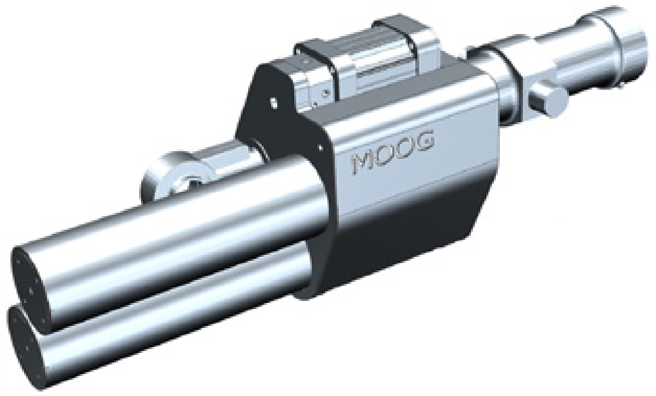

Fig. 4: Autonomous hydrostatic actuator as a sealed system

Example 2: Low inertia motors are the key to the optimum performance of the clamping and injection axes. In this case, Moog's Brushless Servo Motors with outstanding dynamics, offer attractive performance values and lead to improvements not only relating to machine performance, but also energy and production efficiency. In the liquid cooled version, the surface remains cool, thus generating little in the way of thermal air movements. This reduces dust particle migration and allows 'clean' production.

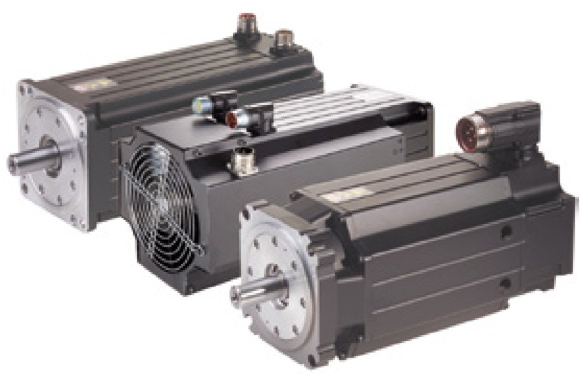

Fig. 5: Moog Brushless servo motor with outstanding dynamics

6 Summary

Injection molding machine manufacturers have the best sales prospects when they consider four key market trends by machine builders: (1.) Energy efficiency, (2.) Production efficiency, (3.) Machine performance and (4.) emission-free production. The requirements that link to these trends can be satisfied by different technologies. A technology-neutral approach is the most economical and represents the largest potential for motion control solutions deliver economy, efficiency and increased performance, thus generaiting a decisive competitive advantage for the customer.

References

[1] AMI report M118, newly grouped by Moog

[2] Engel, Plastics Today.

[3] Moog, interviews with OEMs and Plastics Processors, Q4CY13.

[4] Bonten, Resource Efficiency with Plastics Technology, 2014.

* **John Naisbitt** (born January 15th in Salt Lake City, Utah) is an American author specializing in trends and trends research. His best-known book 'Megatrends' was written in 1982, published in 57 countries and dominated the bestseller lists for several months. Naisbitt is credited with making 'Globalization' a household word.

About the Author

Burkhard Erne, Solutions Marketing Manager in the Industrial Machinery Sector, is a graduate engineer, specializing in Mechanical. He came to Moog in 2005 in the role of Engineering Manager for electro-mechanical drive solutions. Previously, he had led development projects in motion control technology for many years, focusing on solutions to increase the energy efficiency and productivity of plastics processing machinery. Contact him at berne@moog.com.