White Paper

Sustainability: The Megatrend for Plastics Manufacturing Machinery

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Key Messages

- Sustainability is likely to be the decisive megatrend for plastics machinery manufacturing
- The worldwide production of plastics and plastics production machinery continues to rise
- Sustainability, manufacturing efficiency and cost savings need not contradict
- The plastics industry has an image problem
- Key challenge: creation of a recycling focused economy

1 The Plastics Machinery Market

The worldwide production of plastics and rubber machinery has increased continuously in recent years, amounting to approximately € 36.8 billion in 2018 (table 1). Between 2014 and 2018, China was the market leader ahead of Germany, with both countries accounting for more than 50 % of the plastics and rubber machines manufactured worldwide.

Year	Worldwide production in Mio. €	Percentage share					
		EU28	CN	DE	IT	USA	JP
2014	32,536	39.3	33.4	20.5	7.8	7.1	4.2
2015	32,896	39.8	32.5	20.7	7.8	7.2	4.5
2016	34,948	40.8	32.3	21.3	7.7	7.0	4.7
2017	36,312	42,0	31.8	22.1	8.4	7.4	4.9
2018	36,795	42,3	31.1	21.5	7.8	7.1	3.9

Table 1: World production of plastics and rubber machinery (estimates) [12]

After ten years of uninterrupted growth, sales of German plastics and rubber manufacturing machinery are expected to fall by 10 % in 2019, even though there was a 2 % sales increase in 2018 [12]. The main reasons for the decline are [15]:

- Lower investment in the automotive sector
- The plastics industry's image problem stemming from high levels of plastic waste
- Trade disputes
- An overdue economic downturn

For machine manufacturers, understanding customer requirements and objectives is crucial. In autumn 2013, Moog discussed industry developments with manufacturers and users of plastic injection molding machines. According to the survey, the reduction of manufacturing costs was a top priority for plastics processors, centered on energy and raw material savings, the integration of additional production processes and higher machine output. In addition to cost reduction, the focus was increasingly on adapting production conditions to the requirements of food packaging, cosmetics, hygiene and pharmaceutical products. There were four main trends [4].

- Improved energy efficiency
- Improved production efficiency
- Increased machine power
- Contamination-free production

Seven years later, these trends are still a focus of all those involved today. However, a megatrend in the sense of futurologist John Naisbitt (*1929, US-American author with focus on trend and future research) is currently outshining all other topics and poses challenges for the entire plastics and rubber machinery sector: sustainability. The goals of the previous trends and those of sustainability do not necessarily have to contradict each other.

2 The Sustainability Megatrend

Since the Rio Conference in 1992 and the Kyoto Protocol of 2005, sustainability measures have been increasingly implemented within many international and national legal systems, especially in Europe. Manufacturers and operators of plastics and rubber machines, e.g. injection molding machines, are also affected by this development. A good example is the Ecodesign Directive 2009/125/EC, which became law in Germany under the Energy-using Products Act (EBPG). Although the Ecodesign Directive does not apply directly to injection molding machine manufacturers, as less than 200,000 units per year are put into circulation in the EU, it has an indirect effect on them, as components such as electric drives are subject to this directive.

In 2015, the United Nations (UN) agreed on Agenda 2030 for Sustainable Development, and formulated 17 goals for sustainable growth (figure 1).

Due in part to the omnipresent discussion about climate change, plastic waste and microplastics in the oceans, pictures of dead marine mammals and fish with plastic parts in their stomachs and the damaged image of the entire plastics industry that resulted, sustainability is of paramount importance in the plastics machinery industry.

Sustainability has many facets. Increasing energy and resource efficiency, for example, is just as important as better training and good corporate management. Many measures that are originally associated with cost savings also contribute to sustainability. Many trends and developments that are significant for the plastics machinery industry are derived from the megatrend of sustainability [14]. Some particularly important trends are examined in more detail below and Moog solutions for more sustainable machines are suggested.

Like many other industries, the plastics machinery industry is also suffering from the crisis caused by COVID-19. Although some areas are showing growth, e.g. medical technology, a challenging time is ahead. However, the sustainability goals should not be lost sight of. For UN Secretary-General Guterres, the pandemic is an opportunity to act in solidarity and turn this crisis into a push to achieve sustainable development goals - not least because many of the sustainability goals contribute directly or indirectly to minimizing the occurrence and consequences of such pandemics.

3 Responsible Research and Innovation

The EU research framework program “Horizon 2020” has defined responsible research and development as a cross-sectional task. For the plastics machinery industry, this means that technologies and innovations should be evaluated not only in terms of their economic and technical aspects, but also, and especially, with regard to ethical standards. Technological developments should be carried out in cooperation with society wherever possible. In principle, this trend affects all mechanical and plant engineering companies, but due to the global societal focus on plastic waste and the resulting image problem, it is particularly relevant for the plastics machinery sector [14].

Figure 1: The 17 global goals for sustainable development of Agenda 2030, the Sustainable Development Goals (SDGs), are aimed at everyone: governments worldwide, but also civil society, the private sector and science [2]

4 Energy and Resource Efficiency

In the plastics machinery industry the quest for energy and resource efficiency continues. The aim is to manufacture products with as little energy and material as possible. This is not only related to the knowledge of their positive effects on sustainability, but simply to the saving of energy and material costs and the potential increase in profits. Due to the high proportion of energy costs in the total life cycle costs of injection molding machines (figure 2), special attention should be paid to reducing energy consumption, e.g. by using energy-efficient electrohydrostatic drive solutions.

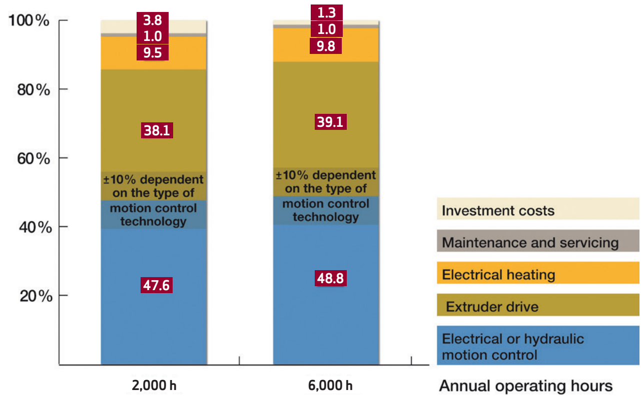

Figure 2: Proportion of the total life cycle costs of an injection molding machine (excluding raw material costs); general conditions: 15 years service life, electricity costs 0.0914 €/kWh, specific energy consumption 0.93 kWh/kg of processed material [1].

Electrohydrostatic drive systems offer machine builders a compact alternative to traditional hydraulic and electromechanical drives. The Moog EAS (Electrohydrostatic Actuation System) is a modular drive concept that combines the Electrohydrostatic Pump Unit (EPU), the Servocontroller (MSD), control blocks and an optional cylinder. Neither a hydraulic power unit nor complex piping is required as is the case with conventional hydraulic systems.

This reduces technological complexity, the number of components, space requirements and the amount of hydraulic fluid needed. The system is pre-assembled and tested at the factory, which drastically reduces installation and commissioning costs as well as ongoing maintenance costs. At the heart of the system is the Moog EPU, which combines the advantages of electric and hydraulic drive technology in a compact, sealed product that offers a high level of energy efficiency and dynamics. For example, a machine builder in the metalforming sector was able to reduce the power consumption of his machine by a double-digit percentage by using the EAS.

Today, most axis are controlled by speed-controlled internal gear pumps and the axis of the plasticizing screw by an electric servo motor with gear box. This enables a low purchase price, high energy efficiency and low rebuild costs. Within the new partnership between Moog and Voith, which was established in the joint venture HMS – Hybrid Motion Solutions GmbH both solutions can be offered.

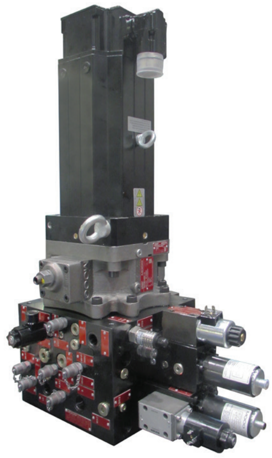

Figure 3: Moog EAS

Injection molding covers a wide range of applications, which is why there are machines of different sizes, performance and repeatability. As a result, there is no single leading technology for drive technology that meets all requirements equally. Electromechanical, electrohydraulic and electrohydrostatic drives coexist - each has specific strengths depending on the application. In order to find the optimum drive technology for a specific application, both in terms of cost and sustainability, the technology-neutral approach should therefore be followed. Depending on the application, requirements and other basic conditions, either hydraulic, electromechanical or hybrid drive solutions can then be implemented. This should apply both to retrofitting (section 7) and to the development of new machines.

5 The Circular Economy

5.1 Facts and Figures

Between 1950 and 2015, manufacturers produced approximately 8.3 billion tons of plastics worldwide, and 2.5 billion tons (30 %) of this total are still in use (as of 2017). The cumulative waste generated from primary and secondary (recycled) plastic waste was 6.3 billion tons. Of this, about 0.8 billion tons (12 %) was incinerated, with approximately 0.6 billion tons (9 %) recycled, of which only a tenth was recycled twice. Around 4.9 billion tons (60 %) of all plastics produced were disposed of and collected in landfills or, even worse, in the natural environment [5]. However, there are large regional differences. While relatively high recycling rates prevail in the EU, the situation is quite different in many other parts of the world.

Region	Millions of tons	Percentage share
CIS	11	3
China	108	30
EU28+NO/CH	61	17
Asia	183	51
Middle East and Africa	25	7
Latin America	14	4
NAFTA	65	18
Worldwide	359	100

Table 4: Global plastics production by region [7]

There is still no sign of any slowdown in the annual growth of plastics production. From 2017 to 2018, global production grew again by 3.2 % from 348 to 359 million tons [7].

Across the EU, the amount of plastic waste grew from 24.5 to 29.1 million tons per year between 2006 and 2018. Fortunately, the recycling rate also increased by 100 % during this period. In 2018, 32.3 % (9.4 million tons) out of a total of 29.1 million tons of plastic waste was recycled, 42.6 % (12.4 million tons) was used to generate energy and 24.7 % (7.2 million tons) was placed in landfill [7].

According to studies by the Helmholtz Centre for Environmental Research, 90 % of plastic waste in the oceans comes from 10 rivers in Asia and Africa. Only a comparatively small part comes from Europe. Nevertheless, sensitivity to this waste problem is extraordinarily high in Europe and the image of plastic suffers particularly in the latter region [8].

5.2 Challenges in the use of Recyclates

Many companies claim that a globally functioning circular economy is both one of the greatest challenges as well as one of the most important building blocks for any improvement in the image of the plastics industry. The potential of plastics is far from being fully exploited here [15].

The EU Commission has defined plastics as one of five priority areas in its Circular Economy action plan. In a paper published by the VDMA in 2018, the majority of the German plastics industry (GKV, Plastics Europe and VDMA) appeared in favor of promoting plastics recycling.

While the recycling rate for glass, metals and waste paper in Germany, for example, is over 90 %, it is much lower for plastics. One important reason for this is the many different types of plastics that are in circulation. These often consist not only of one monopolymer, but different plastics types are frequently combined in one product, rendering the recycling process more expensive.

Many plastics processors fear that recyclates are difficult to process and endanger safe production. However, the quality of recycled plastic materials has improved significantly in recent years, although a key challenge to achieving a functioning recycling economy remains the creation of binding quality standards for recycled materials. Owing to the fluctuating levels of recyclate quality, production cannot be controlled as reliably as it is with standardized virgin material. If recyclate material quality does become more stable, this would make a significant contribution to the acceptance of recycled materials [15].

5.3 Technology for the Separation of Plastics

In order to manufacture high-quality products, plastic material must be as pure as possible. There are already technological solutions for most standard processes such as sorting, crushing and recycling, but these still require refinement and perfecting.

Chemical recycling also appears to be a promising solution for the separation of plastics. The first plants have already begun operating, but it is clear that a degree of pre-separation is still required.

The best solution would be a single-variety collection system. This does not yet exist, but in terms of sustainability, it would minimize the need for costly and energy-intensive mechanical or chemical separation [15].

The cross-process usage of quality data by networking the machines involved (Industry 4.0) can help obtain a better picture of recycled material quality. The better the digital signature of the raw materials, and the better the quality of data from individual processing steps, the better the recycling process will be. If all of the required information is available across the value chain, the more likely it is the process will prove effective [15].

A German company has now developed a sorting technology for the recycling of plastic and fibre composites. Materials are marked with fluorescent, inert tracer substances so that these can then be identified by their fluorescent properties at high throughput speeds, and separated by air valves in the sorting plant. More specifically, for the first time all materials can be separated, regardless of their chemical composition and physical properties [3].

To achieve a functioning recycling economy it is important that this aspect is taken into consideration during the development of new products, and that existing products are checked for their recyclability. So far, there are no binding requirements that would oblige manufacturers to design their plastic products to be recyclable [15].

5.4 Requirements for Plastic Machines and Components

In order for injection molding machines to manufacture plastic parts with recycled materials, it is important to have a clear sense of what the quality of the recycled material is, since impurities and foreign substances can damage the plasticizing system. Measures to prevent this can be filters to remove foreign matter from the recyclate, or more wear-resistant materials in the injection unit for cylinders, screws, etc.

The higher demands that recyclates make on plastics machines and their components can also be met by using other more efficient solutions. In machines with hydraulic drives, for example, highly dynamic, robust, digitally controlled servo valves (e. g. D636, figure 4) with the option for condition monitoring can be used. These valves react quickly and reliably to different process parameters, which is important in terms of repeatability and safely processing high-quality plastic parts with thin walls.

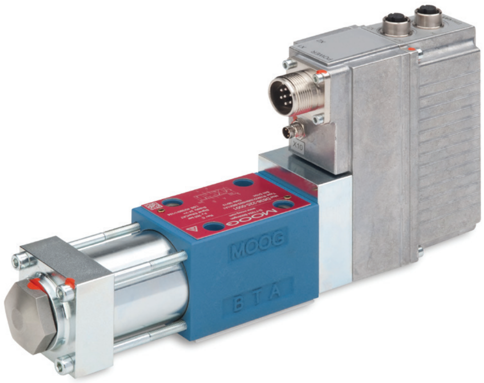

Figure 4: Moog D636 – direct operated servo valve with integrated digital electronics

Some measures can lead to additional costs that are not necessarily required for high-quality recyclate. It is therefore essential that the machine builder clarifies exactly what requirements exist in advance. Depending on the application, it can then be weighed up whether the additional cost for higher-quality recyclate or, for example, that for a more resistant injection unit is the main consideration.

There are currently a number of possibilities for making injection molding machines capable of functioning effectively within the recycling economy. For example, an Austrian machine manufacturer has developed a system that adjusts the quality parameters during the injection process. This works reliably for recyclates, which naturally exhibit significantly greater quality fluctuations between batches than virgin materials, and this enables recyclates to be used more widely.

In the case of molds with sprue systems, plastic waste is produced during each cycle, which can subsequently be ground directly at the machine and continuously fed back into the injection molding process [15].

For some injection molding applications, a certain amount of recycled material can be added to the raw material, thereby reducing material costs. Material costs still account for the largest share of manufacturing costs. There are applications such as transport boxes or drainage piping where 100 % recyclates are often used without any problems. If recyclate is accepted by the customer, the possible result is demand will grow and lead to higher-value products being manufactured. The greater the acceptance, the higher the demand for recyclate and the lower the price.

For higher quality parts typically two or more injection axis are required. In the co-injection process in which the inside part of the part is recycled plastic and the outside part is pure virgin plastic giving the part a perfect appearance.

Even though most machine builders are currently more active in resource-efficient production, some are researching ways of producing products with monostructures that are easier to recycle. To date, this has only been possible with composite materials that are difficult to recycle.

Now could be an opportunity for more intensive research into recycling possibilities so that so-called downcycling does not necessarily take place. The industry could show what can be done with recycled materials and thus increase customer acceptance.

6 Bio-Plastics

In the case of so-called bio-plastics, a basic distinction must be made between bio-based and biodegradable plastics.

Bio-based plastics are at least partly made from biomass. They can be biodegradable, but often they are not. The raw materials are produced from plants rich in starch and cellulose, such as corn and sugar cane. DIN EN 16575 defines biomass as "material of biological origin with the exception of material embedded in geological formations and/or transformed into fossil material".

Biodegradable plastics, on the other hand, decompose under certain conditions and leave only CO2 and water behind during degradation. According to DIN EN 16575, biodegradation is "degradation caused by biological activity, e.g. by enzymatic action, which leads to a significant change in the chemical structure of a product". Biodegradable plastics can be produced from thermoplastic starch, cellulose, degradable polyesters and polylactide (PLA). Some degradable polyesters are also produced from petroleum. Thus, not all biodegradable plastics are bio-based. Blends such as PLA and degradable polyesters are also common. Whether a plastic is biodegradable also depends on the processing and must be determined through experimentation [9].

So far, bio-plastics in injection molding have been more of a niche product, and are most often used where ecological awareness is most acute, for instance in the manufacturing of children's toys or in packaging. However, there are still certain disadvantages regarding their properties compared to conventional plastics [15].

Just like recyclates, bio-plastics also place higher demands on plastics machinery and its components, so this should also be taken into account when selecting the appropriate components (see section 5.4).

Recently, an injection molding machine manufacturer developed an interesting use for biodegradable plastics by developing a special screw that enabled the production of completely biodegradable coffee capsules. Coffee capsules in particular have a bad reputation with regard to waste problems [16].

7 Retrofit

In terms of sustainable production, retrofitting is not the first topic that comes to most people's minds. Retrofit in this context means the modernization or expansion of existing, mostly older machines and equipment.

Plastics machines are normally durable capital assets. On the other hand, innovation cycles are becoming shorter, and the framework conditions, trends and requirements for manufactured products are changing, resulting in a need for modernization.

Retrofitting is a resource-saving way of making a machine more efficient, reducing production costs and making a substantial contribution to sustainability by reducing energy and material consumption. In principle, it can be assumed that the higher the capital value of the machine, the more likely it is that modernization should be considered rather than a new purchase.

For injection molding machines, a retrofit with state-of-the-art drive solutions such as electrohydrostatic drives (EAS, section 4) or, in the case of electric drives, with an MD series servo motor (figure 5) can be useful. Due to their very good acceleration values, the brushless MD servo motors offer the best conditions for casting particularly thin-walled parts and thus contribute, among other things, to low material consumption and the conservation of resources.

Figure 5: Moog Maximum Dynamic Brushless Servo Motor of the MD Series

Retrofitting highly dynamic digitally controlled servo valves can improve repeatability, which allows for lower tolerances and therefore lower material thicknesses. For example, thinner film thicknesses can be achieved in plastic film production or lower wall thicknesses in injection molding. The increased precision could result in fewer rejected parts and higher machine availability can be expected because of the higher quality components.

Condition monitoring platforms are available for many servo and proportional valves, which enable plastics processors to increase machine availability, guarantee consistently high-quality finished parts and reduce energy and material consumption.

Retrofitting modern drive and control technology can be a resource-saving solution for achieving higher energy and resource efficiency in many respects, thus saving costs and contributing to sustainability.

8 Summary

Constant media reporting on the issue of plastic waste and its effects on human society, the environment and the plastics industry has placed the latter under increasing pressure to contribute significantly to sustainability through a variety of measures, especially given the increasing global manufacturing of plastics products. Sustainability has many facets, and measures that have been viewed from a cost perspective to increase efficiency can also contribute to greater sustainability.

This paper presents some solutions with which manufacturers and operators of plastics machinery can contribute to sustainability. Most players are currently focusing on the topic of recycling management, which was one of the most important topics at the K trade fair 2019. Retrofitting or the use of bio-plastics can also play an important role. As is often the case, there are a number of possible approaches, but all of them require a certain amount of conversion and adaptation.

9 References

1. Bonten, C. (2014). Ressourceneffizienz mit Kunststofftechnologie. Universität Stuttgart.
2. Bundesregierung. Nachhaltigkeitsziele verständlich erklärt. Retrieved 01/2020 from https://www.bundesregierung.de/breg-de/themen/nachhaltigkeitspolitik/nachhaltigkeitsziele-verstaendlich-erklaert-232174
3. Eichler, S. (2019). Mit Feenstaub markiert. Retrieved 09/2019 from https://www.brandeins.de/magazine/brand-eins-wirtschaftsmagazin/2019/mit-leichtem-gepaeck/polysecure-mit-feenstaub-markiert
4. Erne, B. (2014). Moog Technical report. Produktions- und Energieeffizienz in der Kunststoffindustrie (mit Fokus auf Spritzgießmaschinen). Moog.
5. Geyer, R., Lambeck, J., & Lavender, K. (2017). Production, use, and fate of all plastics ever made. Retrieved 08/2019 https://advances.sciencemag.org/content/3/7/e1700782
6. PlasticsEurope AISBL (2018). Plastics – the facts 2018. Retrieved 08/2019 from https://www.plasticseurope.org/application/files/6315/4510/9658/Plastics_the_facts_2018_AF_web.pdf
7. PlasticsEurope AISBL (2019) Plastics – the Facts 2019. Retrieved 01/2020 from https://www.plasticseurope.org/de/resources/publications

8 Schmidt, C. (2017). Flüsse tragen Plastikmüll ins Meer. Retrieved 08/2019 from https://www.ufz.de/index.php?de=36336&webc_pm=34/2017

9 Umweltbundesamt. (2019). Biobasierte und biologisch abbaubare Kunststoffe. Retrieved 09/2019 from https://www.umweltbundesamt.de/biobasierte-biologisch-abbaubare-kunststoffe#textpart-4

10 VDMA Vettkötter, I. (2019). „Deutscher Kunststoff- und Gummimaschinenbau erwartet Umsatzrückgang von 10 Prozent für 2019“ [Presseinformation]. Retrieved 09/2019 from https://www.vdma.org/

11 VDMA. (2018). Jahresrückblick Kunststoff- und Gummimaschinen 2017. Retrieved 09/2019 from https://www.vdma.org/

12 VDMA. (2019). Jahresrückblick Kunststoff- und Gummimaschinen 2018. Retrieved 01/2020 from https://www.vdma.org/

13 VDMA (2019) Statistisches Handbuch für den Maschinenbau Ausgabe 2019. Abgerufen 01/2020 von https://www.vdma.org/

14 VDMA. (2019). Trendradar für den Maschinen- und Anlagenbau. Retrieved 09/2019 from https://www.vdma.org/

15 VDMA. Vettkötter, I. (2019). Interviewserie zur Circular Economy. Retrieved 09/2019 from https://www.vdma.org/

16 K Zeitung online (2019). Kaffeekapseln aus Biowerkstoffen und Innenmembran. Retrieved 09/2019 from https://www.k-zeitung.de/ressourceneffizientes-spritzgiessen/

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