Design considerations for modern packaging lines

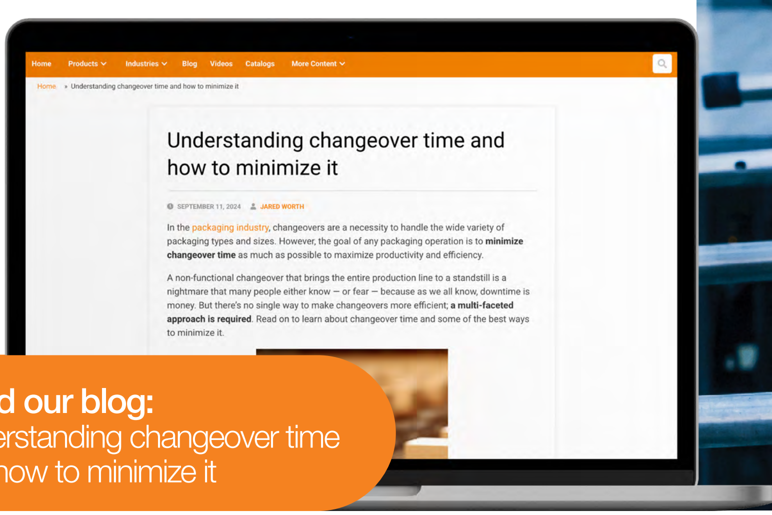
How to achieve more reliable and cost-effective packaging performance

Introduction & background

The industrial packaging sector is currently navigating a dynamic landscape, driven by evolving consumer demands, regulatory shifts, and advancements in technology. For engineers designing these systems and purchasers evaluating new solutions, understanding these underlying market pressures and the resulting operational pain points is essential.

Some of these challenges include minimizing unplanned downtime and overall maintenance time, most often occurring because of inadequate lubrication or the need for relubrication respectively. In food and beverage production this is especially challenging, as equipment needs to be safe for incidental food contact.

This white paper will explore these topics, presenting some of the leading trends and challenges in the packaging industry, as well as ways to design better, more cost-effective solutions with high-performance, hygienic polymer motion components.



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Understanding changeover time and how to minimize it

Packaging machinery trends &

Market pressures

Demands are constantly increasing for the packaging industry, requiring packaging lines to be faster, cleaner, and take up less space. These demands directly influence design specifications and operational requirements of packaging machinery.

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Speed

The never-ending pursuit of larger production volumes requires machines capable of faster cycle times and increased output per minute. This impacts everything from component durability and motion control systems to material handling and sealing mechanisms, demanding robust designs that can sustain high-velocity operations without compromise.

Automation

The need to reduce labor costs, improve consistency, and minimize human error is accelerating the adoption of advanced automation. This includes advanced robots, integrated vision systems, and intelligent control architecture. Machine designs need to be highly adaptable to automation integration and seamless data exchange to implement these systems.

Hygiene

Strict hygiene standards and regulatory compliance (FDA, HACCP) are non-negotiable in packaging, but particularly in the food, beverage, and pharmaceutical sectors. This translates into demand for machines that are easy to clean, resist microbial growth, and prevent cross-contamination.

Space Constraints

Manufacturing facilities are often optimized for maximum production within existing footprints. This leads to a persistent demand for more compact and space-efficient packaging machines that can deliver high performance with minimal floor space. Miniaturization of components, optimized layouts, and multi-functional designs are effective ways to minimize workspace.

challenges

Common pain points

These market pressures often manifest as significant operational pain points for both the engineers tasked with designing these machines and the manufacturers who operate them. Addressing these challenges through thoughtful design is crucial for enhancing overall equipment effectiveness and reducing total cost of ownership.

Wear and Tear

High-speed operation and continuous use inevitably lead to wear and tear on critical machine components. Bearings, gears, chains, and other moving parts are susceptible to fatigue, abrasion, and corrosion, resulting in unplanned downtime for maintenance and costly production losses. Engineers must design for maximum component lifespan and ease of replacement.

Contamination

In sensitive production environments, traditional lubricants pose a significant risk of contamination. The need for food-grade (H1, H2) or even food-contact-approved (3H) lubricants adds complexity and cost, while the potential for lubricant leakage can compromise product safety and lead to costly recalls. This drives demand for lubrication-free or minimal-lubrication solutions.

Frequent cleaning

The necessity of regular and rigorous cleaning, often involving high-pressure washdowns and aggressive cleaning agents, can severely degrade standard metal components. Water ingress, chemical corrosion, and abrasive cleaning methods can damage seals, bearings, and electrical systems, leading to premature failure and increased maintenance.

Space Constraints

Beyond the overall factory footprint, engineers frequently face internal space limitations when integrating components within the machine itself. Compact, integrated solutions and innovative component designs are essential to overcome these internal space restrictions.

Motion systems
in packaging equipment

There are three key types of motion present in packaging lines: rotary, linear, and vertical. Each requires its own considerations to be made, and unique components to facilitate these movements.

Rotary Motion

Rotary motion involves movement in a circular path around a fixed axis. This type of motion is essential for processes requiring indexing, turning, or continuous rotation.

Indexing Tables: These devices use rotary motion to precisely position products or packaging components at various workstations. For example, an indexing table might rotate a bottle to different filling, capping, and labeling stations on a production line, ensuring each process step occurs at the correct location and time.

Rotary Arms: Often found in robotic or automated systems, rotary arms utilize rotational movement to pick, place, or manipulate items. They can be used for tasks such as orienting products, applying labels to round containers, or wrapping palleted products with stretch film.

Slewing rings are commonly used for rotary motion in packaging equipment due to their compact design, smooth motion, and high speed capabilities.

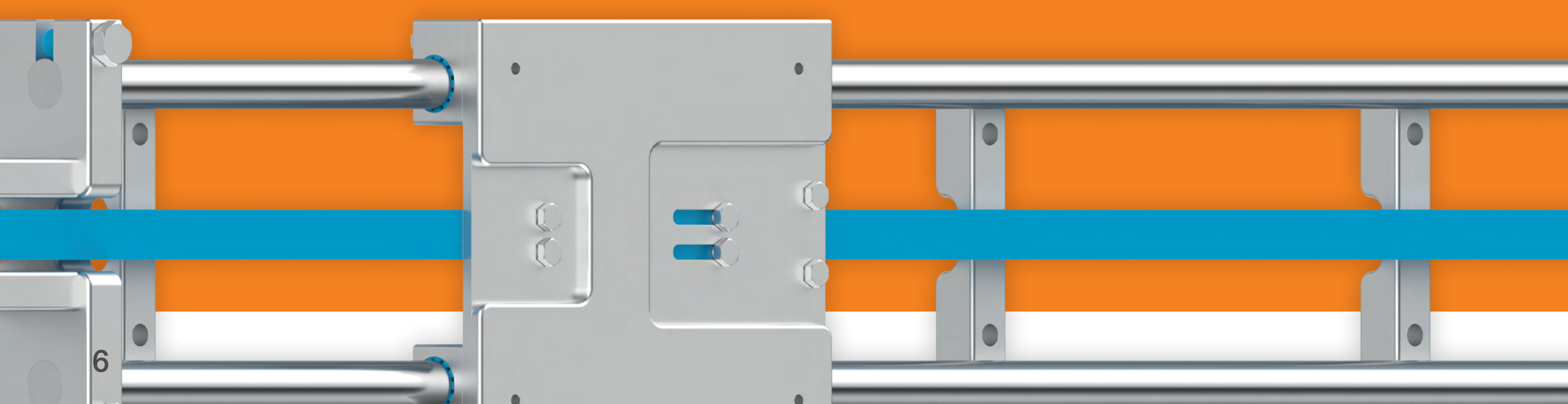
Linear Motion

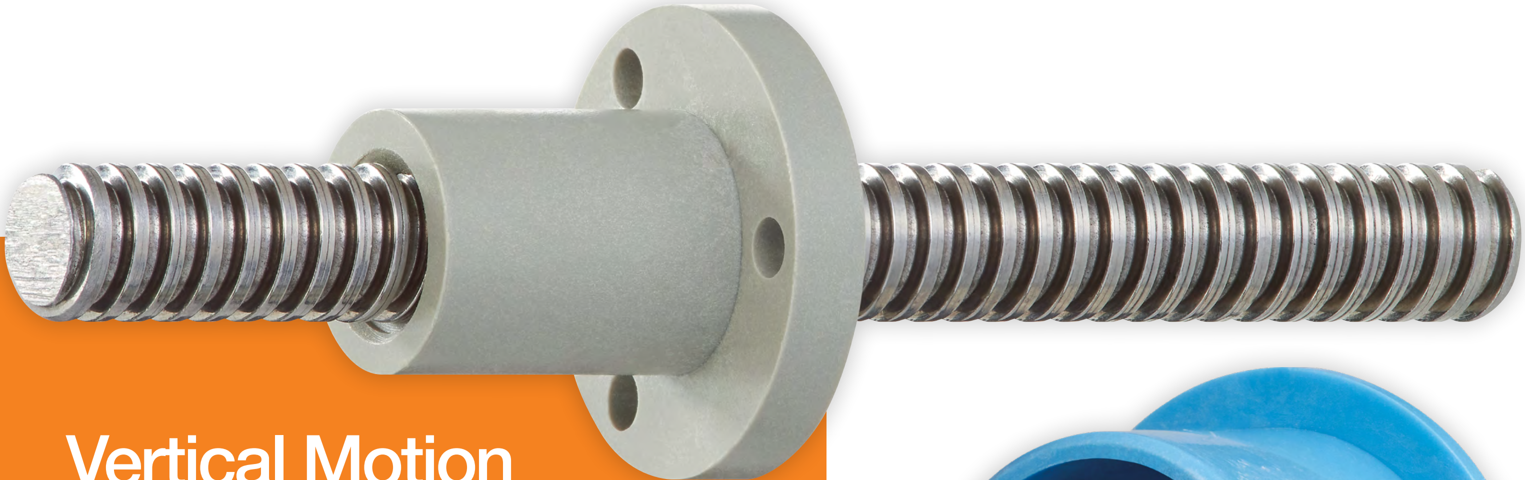
Linear motion refers to movement along a straight line. This is a fundamental motion type for tasks involving pushing, pulling, sliding, or precise positioning over a defined distance.

Sealing Jaws: In form-fill-seal machines, linear motion is critical for the precise closing and opening of sealing jaws. These jaws move linearly to press and heat-seal packaging materials, creating airtight or secure closures for bags, pouches, or trays.

Pick and Place Systems: These systems employ linear actuators to move grippers or suction cups along a straight path to pick up products from one location and accurately place them in another.

Pick and place systems can utilize a variety of motion components, including high helix lead screws, **linear actuators**, **gearboxes**, and **plain**, **linear**, & **self-aligning bearings**. Sealing jaws are more likely to primarily use linear actuators or **gears** for precise control.





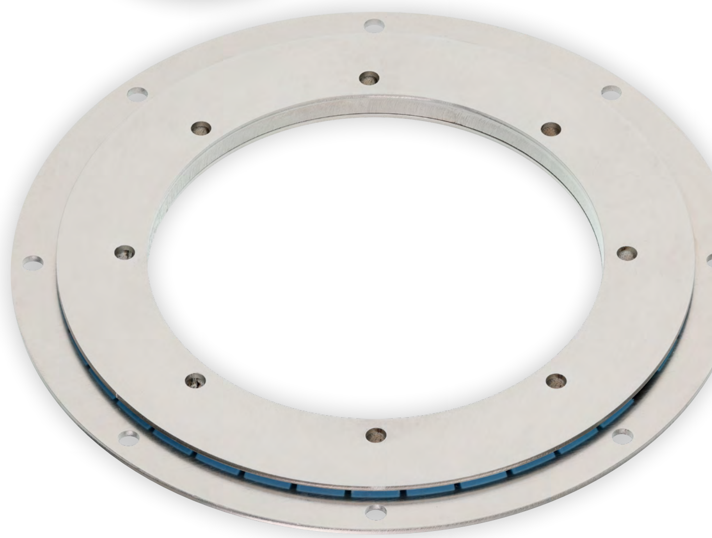
Vertical Motion

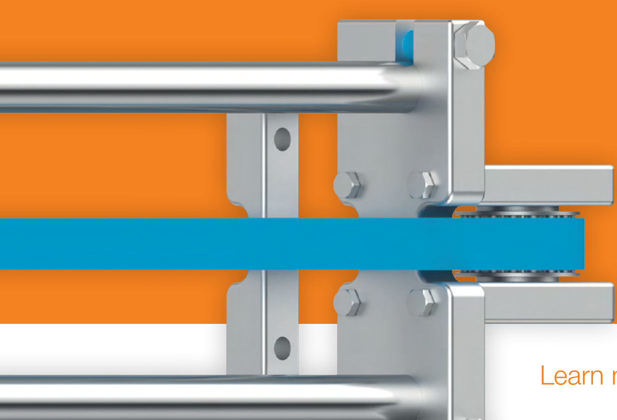
Vertical motion involves movement in an upward or downward direction. This type of motion is vital for tasks requiring lifting, lowering, stacking, or precise vertical positioning of products or machine components.

Lift Gates: In many packaging lines, lift gates use vertical motion to raise or lower sections of a conveyor or transfer products between different elevations. This can be used for ergonomic access, product accumulation, or integrating multi-level processing.

Product Handling Systems: A wide range of product handling applications rely on vertical motion. This includes systems for stacking products into layers, destacking empty containers, or precisely positioning items for filling or inspection.

Linear actuators, trapezoidal or **ACME lead screw assemblies**, and **cable carriers** are especially important for vertical motion. Linear actuators and lead screws act as the driving components — with ACME screws offering self-locking to avoid back driving — and cable carriers to prevent any cables from tangling and getting damaged.





Key design considerations for motion components

The selection of motion components is a critical decision in machine design, directly impacting performance, longevity, operational costs, and compliance. Beyond initial purchase price, engineers must evaluate a range of factors to ensure optimal system integration and long-term success.

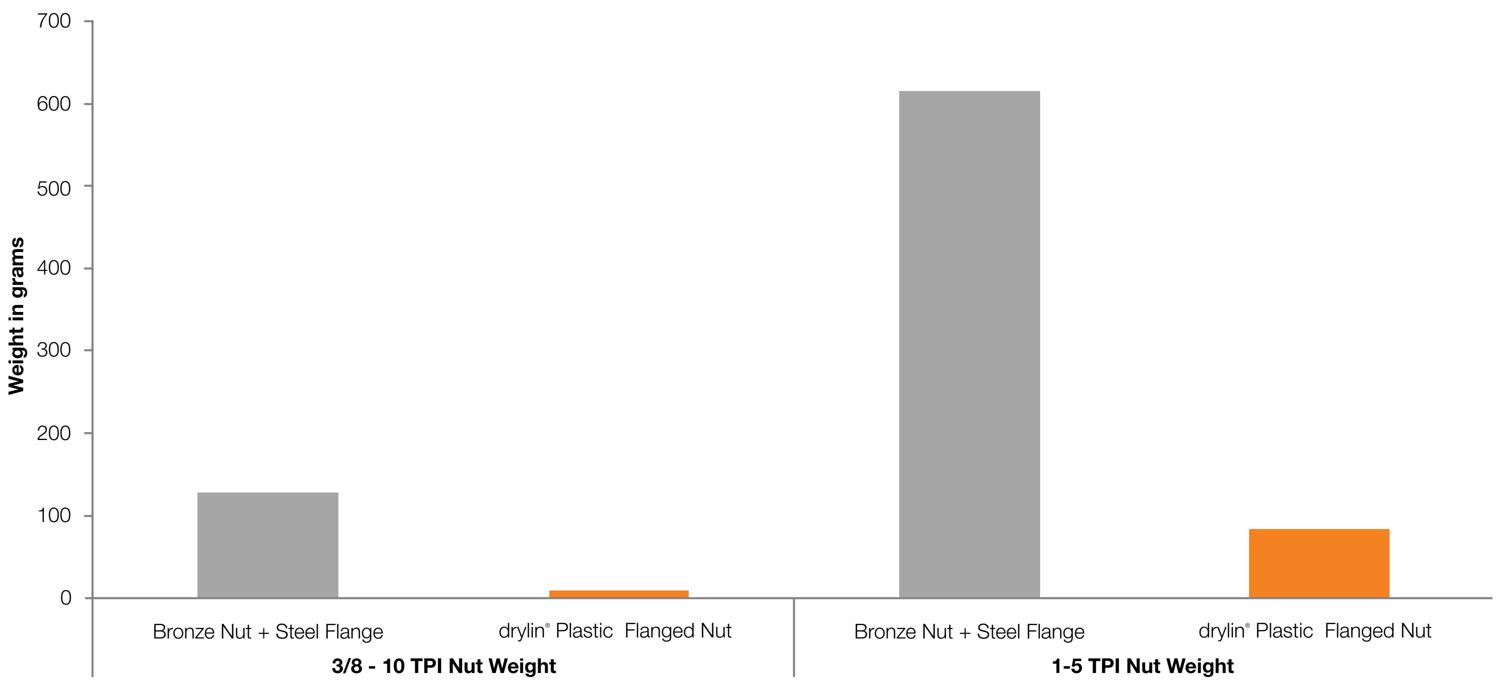
This section delves into key design considerations, highlighting the advantages of advanced material solutions, particularly self-lubricating polymers, in addressing common industrial packaging challenges.

Space & weight constraints

Modern high-speed machines and compact industrial designs frequently demand motion components that occupy minimal space and contribute negligibly to overall system weight. The drive for smaller footprints and higher energy efficiency makes the choice of lightweight, compact components essential.

Polymer parts offer a significant advantage in this regard. Their inherently lower density compared to metals translates directly into lighter components. This reduction in weight can have a cascading effect throughout the system, leading to lower inertia, reduced system load, and ultimately decreased energy consumption.

Lighter components also allow for more compact machine designs, enabling manufacturers to create smaller, more agile, and more efficient equipment without compromising performance. The ability to integrate compact, lightweight polymer solutions is therefore a key enabler for the development of the next generation of high-speed, energy-efficient machinery.



Maintenance requirements

Traditional greased metal bearings, while proven in many applications, often introduce significant maintenance burdens. These include the need for regular relubrication, which can be time-consuming and costly, especially in complex machinery or hard-to-reach areas

The hidden costs of preventative maintenance, such as downtime for servicing, labor expenses, and the procurement and disposal of lubricants, can accumulate rapidly over the operational life of a machine.

Read our White Paper:
The true cost of bearing lubrication

In contrast, dry-running polymer options offer a compelling alternative. These materials are inherently self-lubricating, meaning they do not require external greases or oils for operation. This fundamental difference dramatically extends service intervals, often leading to a "set-and-forget" solution.

By eliminating the need for relubrication, self-lubricating materials reduce ongoing maintenance costs, minimize machine downtime, and simplify operational procedures, contributing to a lower total cost of ownership.

Sanitation & compliance

Environments such as food processing, pharmaceutical packaging, and medical device manufacturing impose stringent sanitation and compliance requirements. The use of traditional lubricants in these settings presents significant challenges due to the risk of contamination. Even food-grade lubricants, while designed for incidental contact, can still pose a risk if leakage occurs, potentially leading to product recalls, regulatory penalties, and reputational damage.

Modern motion components must meet strict standards, including specific IP ratings for washdown resistance, the use of FDA-compliant materials, and robust resistance to aggressive cleaning chemicals. Polymer solutions are particularly beneficial in washdown zones. Their inherent self-lubricating properties eliminate the need for external greases, preventing the accumulation of dirt and the potential for bacterial growth.

Many high-performance polymers are also engineered to withstand harsh chemical cleaning agents and high-pressure washdowns, ensuring long-term integrity and compliance with hygiene regulations without compromising operational efficiency.

Durability & environmental resistance

Industrial environments are often characterized by challenging conditions, including the presence of dust, water, significant vibration, and extreme temperature swings. Traditional metal components can be susceptible to wear and corrosion in such demanding settings, leading to premature failure and increased maintenance.

Dry-running components, particularly those made from specialized polymers, are inherently designed to excel in these conditions. Their material composition often provides excellent resistance to ingress from dust and water, and their self-lubricating nature means that external contaminants do not interfere with lubrication.

Many polymer bearings and linear guides are also highly resistant to corrosion, unlike their metallic counterparts, which can rust or degrade when exposed to moisture or corrosive substances. This resilience ensures consistent performance and extended service life even in the most aggressive environments.

Manufacturers like igus provide extensive test data and sophisticated lifetime calculation tools, such as service life calculators, enabling engineers to accurately predict component performance and durability under specific environmental loads.

Performance & ROI cost-benefit perspective

Focusing too closely on just upfront costs of parts can lead to significant oversights in long-term financial performance. A comprehensive cost-benefit analysis that encompasses total cost of ownership (TCO) and the tangible return on investment (ROI) must be conducted early in the process. Doing so can reveal how seemingly higher-priced, high-performance components can actually deliver substantial savings and operational advantages over their lifespan.

Total cost of ownership vs. upfront component costs

The true economic impact of a motion component is not only determined by initial price tag, but all direct and indirect costs associated with it throughout its service life. While upfront component costs are a necessary consideration, they're ultimately only a fraction of the overall cost of a component. TCO encompasses:

Acquisition Costs: The initial purchase price of the component.

Installation Costs: Labor and resources required for integration into the machine.

Operating Costs: Energy consumption, lubrication, and consumables.

Maintenance Costs: Scheduled preventative maintenance, unscheduled repairs, labor, and replacement parts.

Downtime Costs: Lost production, missed deadlines, and potential penalties due to machine unavailability.

Disposal Costs: End-of-life expenses for component replacement and waste management.

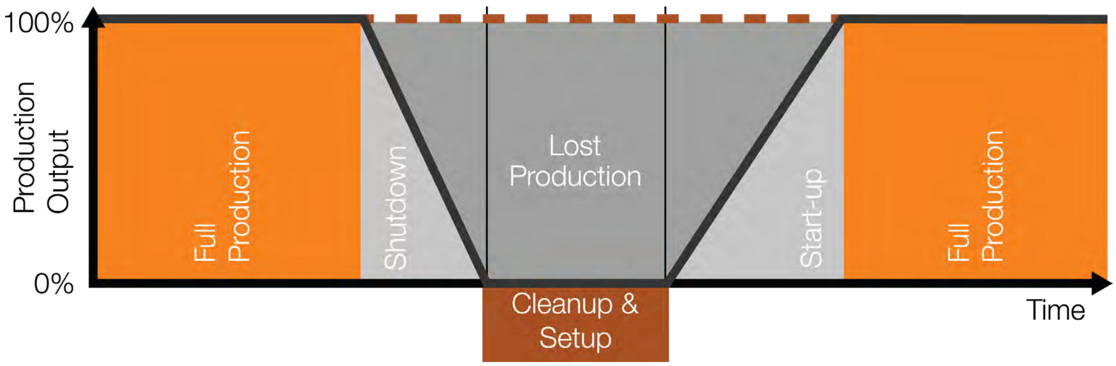
By shifting focus from upfront costs to TCO, manufacturers can identify components that offer superior long-term value through reduced operational and maintenance expenses.

For example, a self-lubricating polymer bearing may have a slightly higher unit costs than traditional greased metal bearings, but by eliminating lubrication costs, reducing maintenance labor, and extending service life, TCO is significantly lowered over a five or ten-year span.

Minimized
changeover times

Changeovers are prevalent in every packaging line, and are a necessary source of downtime. Low-quality components and systems can lead to inefficiencies in the changeover process, extending changeover times and reducing overall throughput.

While this may seem like a minor issue on the surface, some packaging operations require multiple changeovers in a single day. In these cases, what may only be a delay of a few minutes per changeover can lead to dozens, if not hundreds of hours of lost production time per year.



Reduction in maintenance
and unplanned downtime

Two of the most impactful factors influencing TCO and ROI are the reduction of maintenance hours and the prevention of unplanned downtime. These elements directly translate into operational efficiency and profitability.

Reduction of maintenance hours: Components that require little or no lubrication, resist wear and corrosion, and have longer service lives inherently reduce the labor hours dedicated to maintenance. In some cases — such as Heineken's bottling facility in Brazil — this can save well over 1,000 hours of labor annually.

Unplanned downtime: Arguably the most significant hidden cost in packaging lines is unplanned downtime. Production is halted completely when a machine breaks down, wasting materials and delaying order fulfillment. These costs can quickly escalate, far outweighing initial savings from choosing cheaper, less reliable components.

High-performance, durable motion components significantly mitigate the risk of unplanned downtime. Their robust design and predictable service life ensures reliable, long-lasting performance — improving ROI and operational stability in the long-term.

Conclusion

While requirements in the packaging industry are constantly growing to match increased demands, regulations, and technological capabilities, it's still possible to develop long-lasting and reliable packaging lines at an affordable price point. Polymer motion component manufacturers like igus® can assist in this process, providing high-performance parts, expert advice, and online configuration tools to ensure your design is successful.

Get started with an igus expert today!