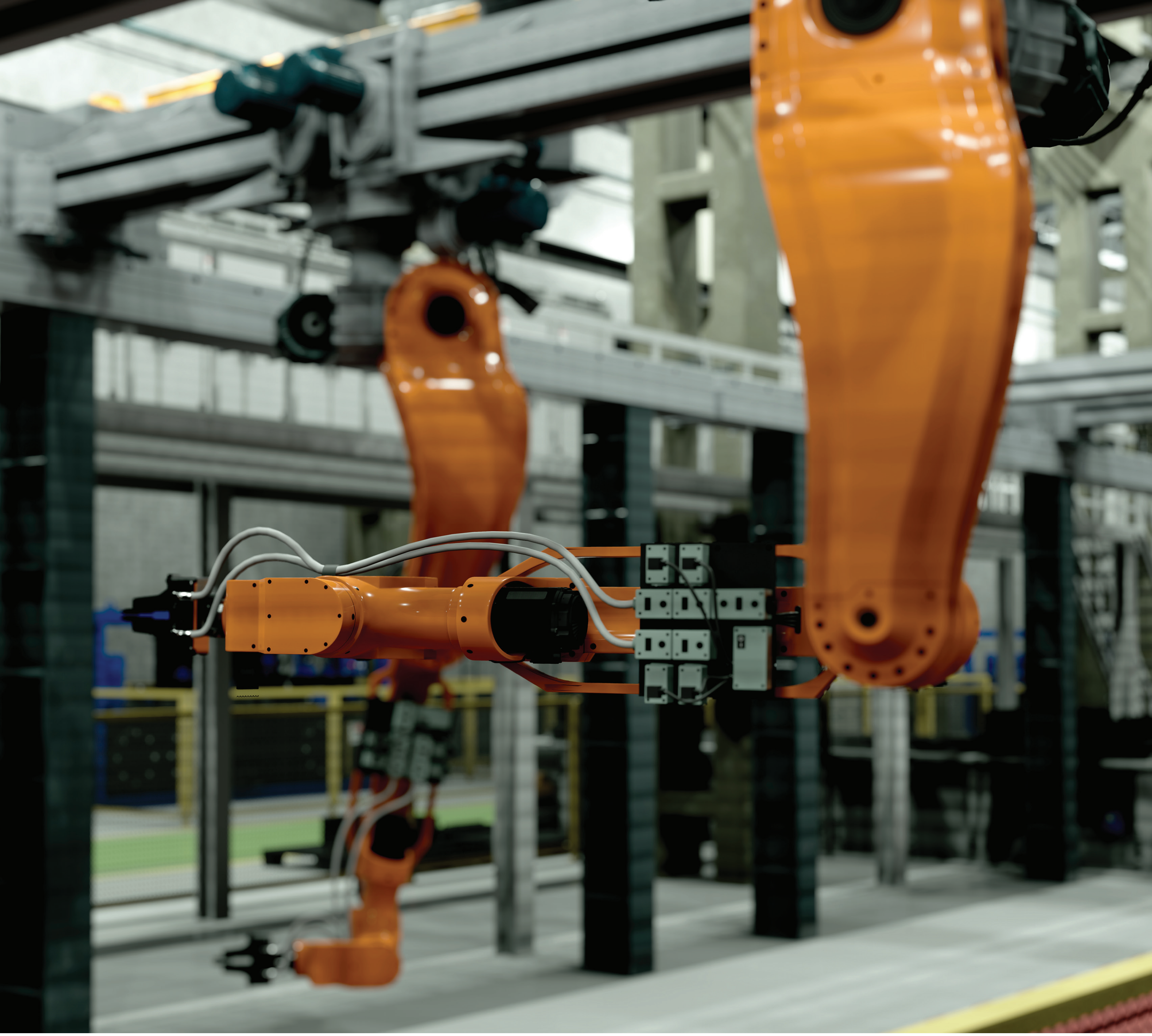

Trends in Industrial Manufacturing Equipment Drive Innovation in Metals, Automotive, and Rubber & Plastics Industries

ENGINEERING YOUR SUCCESS.

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The fourth major industrial manufacturing transformation has begun, frequently referred to as "Industry 4.0."

It includes the addition of smart and autonomous systems partnered with data and machine learning. This will result in smart factories, where assets, processes, people and devices are all connected. Cyber-physical machines will monitor physical processes, create and share information with each other, and make decisions without human involvement. They will use the industrial internet of things, big data, cloud computing, cognitive computing and AI to maximize plant efficiency and productivity while reducing costs and waste.

In a recent Deloitte survey, 86% of U.S. manufacturers thought that "*smart factories will be the primary driver of competition by 2025*," and 83% felt they "*will transform the way products are made*." In the same survey, 35% of U.S. manufacturers said they had converted at least one factory to smart status or were "currently implementing initiatives related to smart factories." The remaining 65%, however, had not yet acted to move their companies in this direction.

Certain trends are expected to impact many of industrial manufacturing equipment's key segments, including metals, automotive, and rubber & plastics.

In the next five years, industry advances will include the processing of stronger, lighter materials that are replacing steel, machines that produce more complex parts with smaller tolerances at higher speeds, smart "cobots" and SCARA robots operating alongside factory workers, and software that incorporates machine monitoring, reporting, and predictive diagnostics.

This white paper includes both global and U.S. market trends that are driving new thinking, designs, and technologies.

Metals Industry

Metalworking machinery typically takes raw steel, aluminum, or metal alloys and processes it into shapes and intermediate and finished parts and products. This sector encompasses a variety of equipment, including:

- Metal cutting machine tools *(lathes, power saws and planers, and drilling, milling, hobbing, honing, broaching, grinding, and some CNC machines)*
- Metal forming machine tools *(punching, shearing, bending, forming, stamping, pressing, forging, die-casting, extruding, and some CNC machines)*
- Cutting and machine tool accessories and attachments
- Special dies, tools, jigs, and fixtures
- Industrial molds for casting metals
- Rolling mill machinery and equipment for metal production
- Assembly machinery
- Coil handling, conversion, and straightening equipment
- Wire drawing and fabricating machines

U.S. and Global Markets

According to the U.S. Census Bureau (Annual Survey of Manufactures), U.S. manufacturers' sales of metalworking machinery in 2019 totaled $31.8 billion. Of this amount:

- 27% was special tool and die, die set, jig and fixture manufacturing
- 25% was machine tool manufacturing
- 19% was industrial mold manufacturing
- 17% was cutting and machine tool accessory manufacturing
- 11% was rolling mill and other metalworking machinery manufacturing

(This data does not include U.S. imports. It does not represent the total U.S. market for metalworking machinery.)

Worldwide, due to the pandemic, global machine tool consumption fell from $85.6 billion in 2019 to $65.7 billion in 2020, a drop of 23.2% according to the German Machine Tool Builders' Association (VDW) and Oxford Economics. Supply and demand were negatively impacted by labor shortages, reduced orders, and shipping disruptions which affected global supply chains.

A partial recovery of 17.7% is predicted for 2021, with figures expected to reach $77.4 billion. Assuming global machine tools represent 25% of global metalworking machinery sales (as in the U.S.), the global market for all metalworking machinery is estimated to reach $310 billion in 2021.

Equipment Design Trends

Equipment design improvements are driven by specific customer requirements:

Higher productivity:

- Machine reliability
- Reduced downtime
- Predictive diagnostics
- Improved throughput
- Improved precision
- Improved motion control performance

Lower costs:

- Energy savings

Improved work environment:

- Safety
- Quiet operation
- Ease of machine controls
- Smaller footprint (floor space)

Environmental concerns:

- Reduce carbon footprint

Broader Industry Trends

CNC Machine Tools

One of the fastest growing markets in metalworking machinery is computer numerically controlled (CNC) machine tools. All their operations are pre-programmed, which enables them to turn out complex, high-precision parts in high volumes. These machines reduce operating costs, including labor and manufacturing errors. They are also adaptable to IoT technologies and predictive analytics. By 2026, the global market for CNC machine tools is expected to reach $129 billion, growing at an annual rate of 5.5%.

Predictive Diagnostics

The integration of sensors, monitoring devices and software enables machines to track and report on their own performance, alerting operators to problems. This enables downtime to be scheduled rather than having an emergency shutdown when the part fails. A wide range of sensors are now available that are small and accurate, able to continuously measure and report on different machine variables and operating conditions.

Continuing Labor Shortages

Manufacturers were suffering from labor shortages before the pandemic, and this problem will likely persist after the recovery. The most experienced factory workers are retiring, and an increasing number of young people are choosing other occupations. These factors are expected to spur growth in labor-saving automation and digitally driven processes. The latter may even attract and help retain young people in the profession. Many modern machines incorporate features that make them easier to use and more relatable to younger employees, such as touchscreens, app-like controls, and intuitive software.

Increasing Focus on Aftermarket Services

Global equipment manufacturers are offering more aftermarket services to customers, including maintenance, service agreements, spare parts and other value-added services, which have a higher profit margin than sales of original equipment. Services also allow manufacturers to smooth out their income stream during a slow economy.

It has grown difficult for OEMs to find qualified service techs, especially as older technicians retire, and machines are becoming more complex with the addition of digital technologies. As a result, manufacturers are shifting customer service to online platforms. Some OEMs can now access their machines directly through a VPN, enabling technicians to troubleshoot and solve problems remotely to avoid the time and cost of onsite visits.

Automotive Industry

New trends in the automotive industry are driving changes in the machines used to manufacture and assemble motor vehicle components.

Stamping presses are critical machines for producing numerous vehicle components such as car doors, hoods, floor panels, undercarriages, and battery trays. Presses are used in both OEM stamping plants and in independent stamping operations that produce OE and aftermarket parts.

These parts can be made traditionally, with one stroke of the press, or the metal can be fed continuously through the machine to a succession of different die stations. Each one performs a specific operation on different areas of the metal.

This latter process, progressive die cutting, is done on transfer presses. These presses are highly efficient due to their speed in making complex, high volume parts.

Recent trends in automotive stamping presses:

Press sizes are getting larger, moving away from smaller machines in the 100–300 ton range with a growing focus on presses with 1,000–2,000 ton or higher capacities. Larger bed sizes are also increasingly desirable. For example, presses that run 42-inch-wide coils of steel. They can make large, completed parts rather than components that require further assembly.

The industry's focus on safety, strength, and weight reduction have resulted in **steel castings and forgings being replaced by high-strength aluminum components.** This has led to stamping presses incorporating servo motors. **Servo presses** are replacing some traditional mechanical presses.

Hydraulic presses, powered by hydraulic cylinders, have the highest tonnage capacities and are more reliable than other types of presses, but they lack the efficiency, speed and precision of pneumatic presses. Traditional hydraulic presses use over-powered hydraulic systems, where the hydraulic pump and an unregulated electric motor run continuously at maximum motor speed. These systems typically have large hydraulic reservoirs and additional add-on cooling systems to burn off the excess power. Put simply, inefficient hydraulic systems generate heat and noise.

According to Dan Detweiler, VAS and Technical Services Manager of Parker's fluid power team, modern hydraulic presses can see vast performance improvement with an up-to-date motion control system such as Parker's Drive Controlled Pump (DCP) technology, combining electronic and hydraulic technologies. "While the traditional hydraulic cylinder is still the workhorse, added to that are an AC drive, a matched hydraulic pump, and a variable frequency drive (VFD) rated electric motor. Software pulls it all together and ensures optimum performance by matching hydraulic flow and pressure to the demands of the press throughout the production cycle."

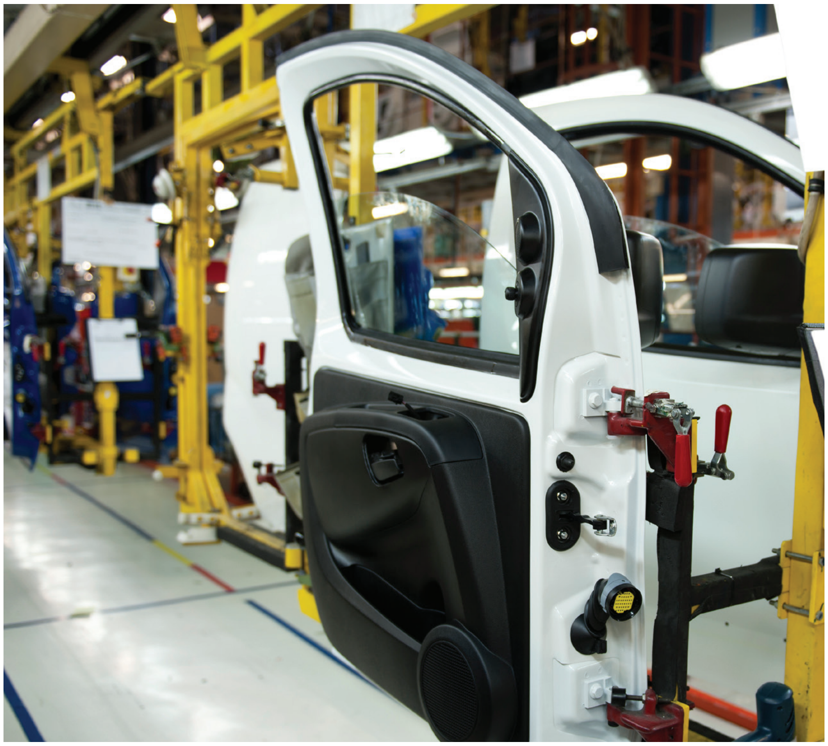
A properly designed system will significantly reduce energy consumption, generate considerably less heat and noise, improve production cycle time, and improve overall press performance. "Used in combination with high-speed, closed-loop, servo-proportional valves and a solid hydraulic motion controller, the press' positioning can be highly accurate and repeatable. These presses can also incorporate production data acquisition, process monitoring, and remote diagnostics," Detweiler says.

Other automotive manufacturing trends affecting production equipment:

Industrial robots have been used in automotive manufacturing since the 1980s. Today, a new type of robot is gaining ground: **collaborative robots, or "cobots."** They work alongside and assist assembly workers, stopping if they encounter a person.

Cobots can work nonstop on repetitive tasks that are difficult for humans. They also assist workers, for example, by holding something heavy in place while the employee works on the part. Their lightweight arms can be easily programmed and redeployed, making them flexible and cost-effective. They can also be "taught" complex tasks.

New lightweight materials will continue to replace traditional iron and steel alloys in motor vehicles. These materials include advanced high-strength steel, aluminum, magnesium, high-performance plastics, carbon fiber and other composites, providing significantly less weight but comparable strength. These attributes are especially important in electric vehicles, where increases in efficiency extend their battery range or enable a smaller battery to provide the same range as a previously larger one.



Advanced high-strength steel (AHSS) is comprised of a family of steel grades, most with yield strengths greater than 550 MPa. Each one is uniquely engineered with different chemical compositions and microstructures to meet different automotive requirements, the most critical being the combination of higher strength and lower weight. AHSS can reduce a vehicle's total weight by 25%–39% compared to conventional steel, while improving its safety and crashworthiness.

For steel sheet and coil used in presses, ductility (formability) is a third major requirement. AHSS grades are designed to be cold formed in traditional stamping machines at room temperature. This can be challenging because higher strength materials are usually more susceptible to different types of deformation during processing. The reduced thickness of AHSS increases its tendency to wrinkle. In addition, processing AHSS in presses causes greater die wear, which has led to the development of dies made of tool steels and to more protective die coatings.

Third generation AHSS grades are under development with tensile strengths beyond 1,200 MPa and with improved ductility.

Plastic components in automobiles are forecast to grow from 5%–10% of total vehicle weight currently to 15% by 2040, according to the Center for Automotive Research. This will be partly due to new capabilities in the production of under the hood components from advanced molding and thermal press technologies. New technologies for joining multiple materials and for industrial 3D platforms also will be developed.

Due to their high cost, **carbon fiber components** are used primarily in high-end sports cars and some luxury vehicles for greater speed, better aerodynamics and fuel efficiency. Other applications are being developed to reduce the weight of shipping trailers and to reduce noise and vibration from wheels for quieter vehicle cabins.

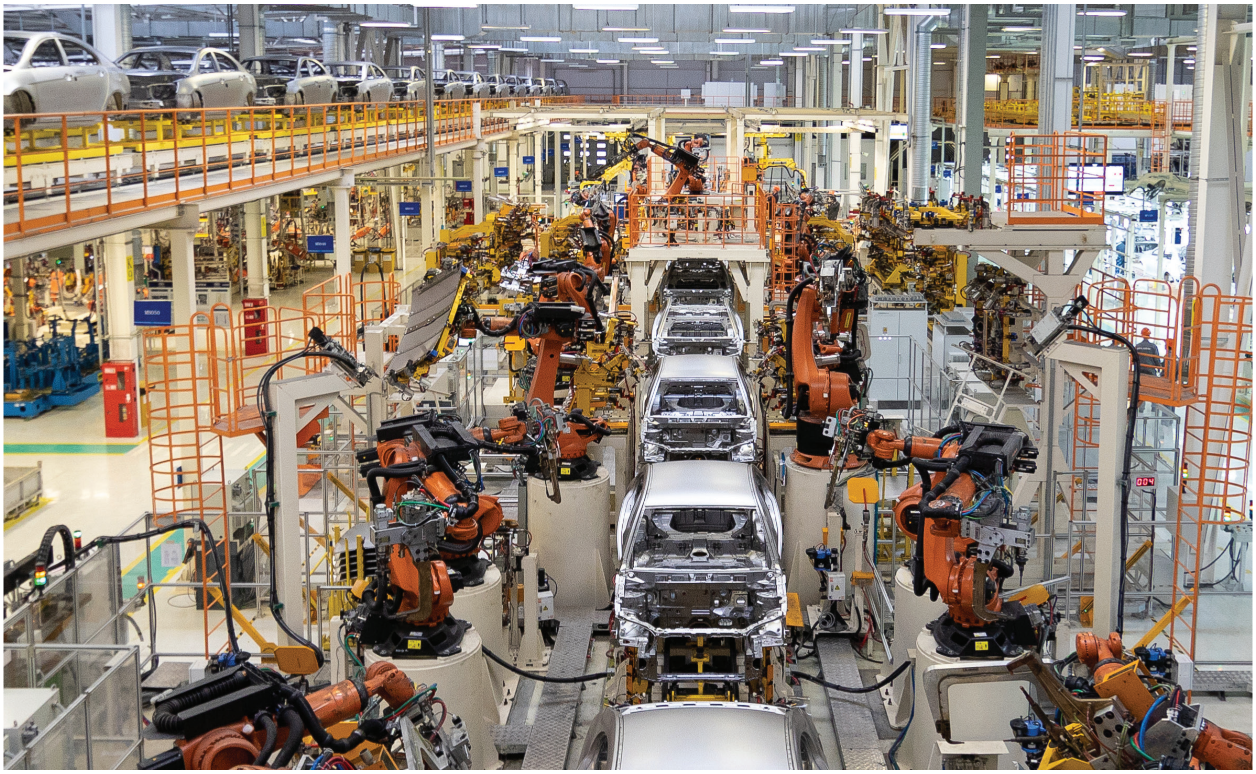
In the future, some automotive assembly plants will likely replace their traditional conveyor systems with **flexible-cell manufacturing.** This is a system where smart automated guided vehicles transport car bodies only to the assembly workstations needed for their specific model, rather than stopping at every station as they do now. Flexible-cell manufacturing is a leaner system that reduces the average time it takes to complete the assembly of each vehicle. Porsche has installed a flexible-cell system in its new *Taycan* production facility in Germany.

Flexible-cell manufacturing can also help manage the **greater complexity anticipated** in future automotive production, namely:

- Faster introduction of new vehicle models into assembly plants
- More vehicle variations due to greater customer personalization
- Fully customizable interiors of new autonomous vehicles
- The need for OEMs to produce models with electric, hybrid, and internal combustion engines as the industry transitions to electric vehicles

3D printing already is used widely for prototyping of newly designed parts but improvements in additive technologies are enabling manufacturers to use it to create production tooling and end-use parts. 3D printing also is being increasingly adopted by automotive OEMs to make replacement parts.

There is an emerging trend of mass customization for consumer vehicles, leading to smaller volumes of varied components such as different colors of exterior paneling, LED trim lighting and door sills, and individualized dashboards. Many of these parts, including one-off gear-shift knobs and key rings, are being 3D printed.



Rubber and Plastics

Over half the world's plastics (51%) are produced in Asia, with China accounting for 31% of the total in 2019. The remaining 49% are made in North America (19%), the EU (16%), the Middle East and Africa (7%), Latin America (4%), and the CIS countries (3%), according to PlasticsEurope.

Packaging is the largest global end use industry for plastics, which consumed approximately 40% of the world's total plastics production prior to 2020. Other major end-use markets are building and construction (16%–20% of global production), textiles (15%), consumer and institutional products (10%), transportation, primarily automotive (7%–10%), electrical/electronics (5%–6%), and industrial machinery (1%).

Rubber and plastics manufacturing machines process and convert resins, polymers and recycled rubber and plastics into finished goods. This equipment is comprised of five broad segments, according to production volume data from Germany's Federal Statistical Office:

- 35% Extruders
- 26% Injection molding machines
- 6% Molding presses
- 3% Cellular rubber and cellular plastics machines (produce rubber and plastics as an air-filled matrix, such as foam rubber)
- 29% Pre-processing and subsequent processing machines (for example, mixers, kneaders, cutters, grinders and granulators, with the latter two used for tire recycling)

There are three basic types of plastic injection molding machines, each with advantages and disadvantages:

Hydraulic IMMs: First introduced in the 1930s, these machines are still the strongest, with clamp forces that can exceed 8,000 tons. Compared to all-electric IMMs, these machines have some downsides. They consume 30%-70% more energy, are noiser and are less precise.

Electric IMMs: Introduced in Japan in 1983, all-electric IMMs comprise over half of all the injection molding machines sold in the U.S. Compared to hydraulic IMMs, they are much faster and can run a job unattended with higher precision and repeatability. They cost more than hydraulic IMMs. They also have clamp parts that can wear out and are expensive to replace.

Hybrid IMMs: Introduced around 2000, hybrids have become increasingly popular in recent years. They have the precision, repeatability, energy savings and reduced noise of all-electric machines but also deliver the powerful clamping force of full-hydraulic machines. The machine's cost is in between that of a hydraulic and an all-electric IMM, with a faster ROI.

Single-screw plastics extruders can melt any raw thermoplastic and run it through a custom-shaped die to form a high-volume, continuous profile. Common products include rubber and plastic pipe and tubing, weatherstripping, fencing, deck railings, window frames, and wire insulation.

Twin-screw compounding extruders are the most frequently used machine for continuously mixing of polymers with additives and fillers. These machines also play a role in recycling. They are used, for example, to mix ground rubber particles from used tires with EVA polymer for flooring, profiles or injection molded parts. They also reprocess PVB, the plastic sandwiched between the layers of safety glass in car windshields, into a value-added product.

Rubber manufacturers also use injection molding machines and extruders. Injection molding machines are used to make rubber gaskets and seals for the automotive industry, as well as molded rubber products for the medical, pharmaceutical, food and aerospace industries. Tire manufacturers use computer-controlled extruders to heat, blend and pressurize the materials before shaping tire treads and sidewall profiles.

Industry trends impacting plastics production machines include:

The demand for parts with lower weight, durability and design flexibility support the **continued growth of reinforced plastics,** now a $16 billion global market. The automotive industry consumes carbon-, glass-, and graphite-reinforced plastics. The use of these and other reinforced plastics also is growing in the medical, construction, aerospace and defense industries.

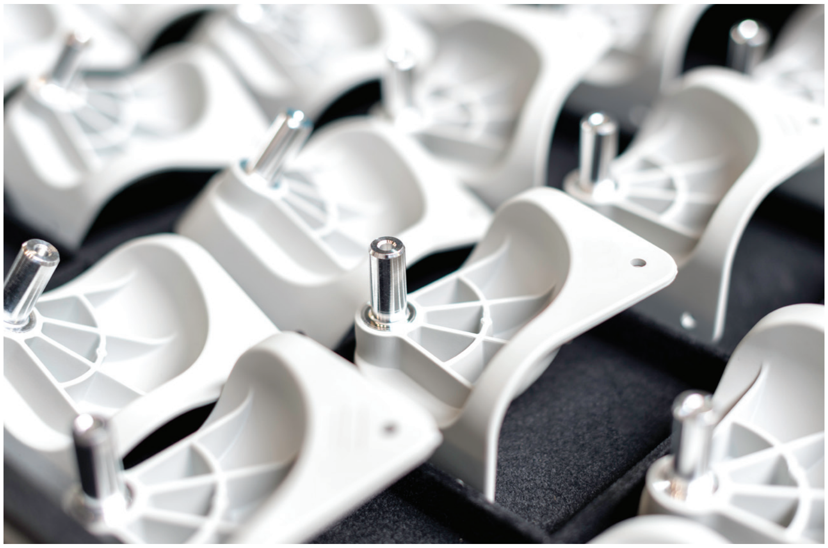
Advances in medical technology have spawned the growth of implantable medical-grade plastics. One trend making this possible is **micro molding,** an injection molding process for making precise, miniaturized plastic parts that typically weigh between 0.1 and 1 gram. The North American market for these tiny parts is expected to grow about 12% annually between 2020 and 2025, from $330 million to $579 million.

Environmental concerns are impacting the global plastics industry, especially waste and recycling. Pressure is increasing for plastics manufacturers to institute plans for handling and disposing of plastic scrap. Environmental concerns are driving the growth of **bioresins/bioplastics** and **prodegradant concentrate resin additives,** which make plastic waste biodegradable.

3D printing technology continues to advance, with recent improvements that reduce cycle times. This enables low-volume production runs of several hundred plastic parts previously made on injection molding machines. The technology also includes more efficient molds with printed-in cooling channels. Polymers are currently the largest 3D materials segment, followed by metals and ceramic.

New software in injection molding machines improves the quality and accuracy of part and mold designs. Software is also able to simulate how melted plastic will flow during the process to better correct defects in advance.

As elsewhere in manufacturing, **robotic automation** is growing in the plastics industry:



- **SCARA robots** (selective compliance assembly robot arm) have proven useful for unloading molding machines, which they can do faster than humans.
- **Automated systems that integrate 4- and 6-axis robotic arms** are performing a variety of other plastics operations such as assembly, dispensing adhesives, sealing, tapping, painting and coating, laser cutting, polishing, parts transfer, and palletizing.
- Plastics producers are using **smart visual recognition technology and sensor systems** for line tracking and picking tasks, which can significantly improve machine cycle times.

According to the (U.S.) Plastics Industry Association, North American shipments of new injection molding and extrusion machinery grew 19.3% in the fourth quarter of 2020, compared to the same period in 2019. This is being sustained by demand for plastics end products, which began growing again in the second half of 2020. While some packaging and medical segments remained strong through the pandemic, other end-use industries, such as automotive, are not expected to return to pre-pandemic levels before 2022. After that, U.S. plastics shipments should return to their steady 2.3% annual growth, experienced since 2010.

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