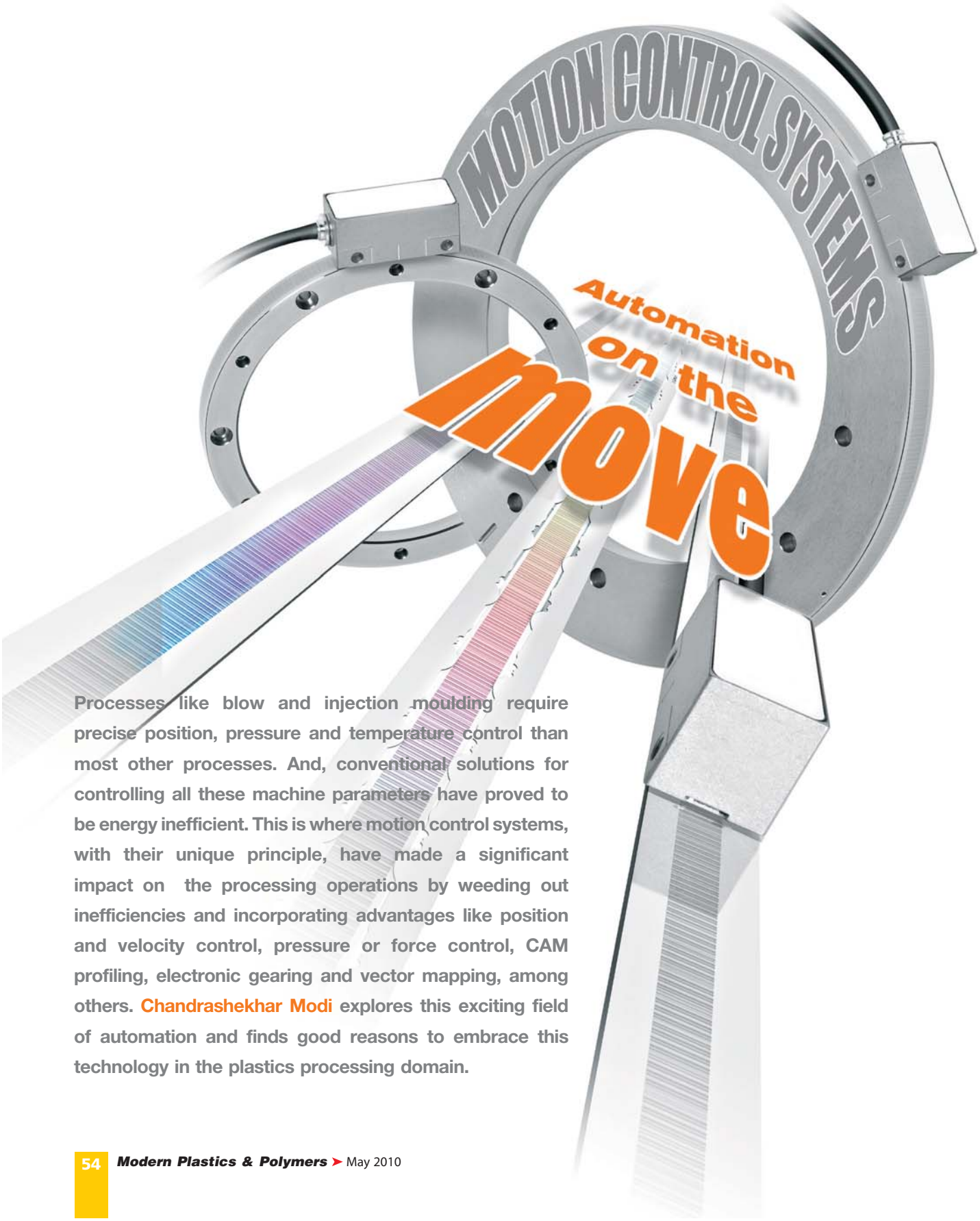


Automation on the move

Processes like blow and injection moulding require precise position, pressure and temperature control than most other processes. And, conventional solutions for controlling all these machine parameters have proved to be energy inefficient. This is where motion control systems, with their unique principle, have made a significant impact on the processing operations by weeding out inefficiencies and incorporating advantages like position and velocity control, pressure or force control, CAM profiling, electronic gearing and vector mapping, among others. **Chandrashekhar Modi** explores this exciting field of automation and finds good reasons to embrace this technology in the plastics processing domain.

Thomas Wittek
executive director, Baumuller India Pvt Ltd

Motion controlled drives and torque motors score well with significantly better power density and an extended range of speeds fulfill lower energy requirements. This opens up new application areas as well as improves productivity in existing ones.

Globally, there has been an increasing demand for flexible, customised, fast and energy efficient machines for injection moulding and blow moulding operations. Machine concepts are becoming more and more modular and the need for sophisticated motion control is on the rise. In line with this, motion control systems provide machine manufacturers greater freedom and flexibility to build 'modular' machines that help reduce power consumption, cycle time, noise levels and facilitate outstanding quality control. A decentralised concept is breaking the machine into virtual mechatronic units that are easy to automate by using pre-programmed or customised software templates.

Motion control is a sub-field of automation, in which the position and/or velocity of machines are controlled using some type of device. These include hydraulic pump, linear actuator, or an electric motor, generally a servo. An important part of robotics and CNC machine tools, motion control is now penetrating the plastics processing arena.

Basic architecture

In motion control systems, position, velocity and sometimes torque are controlled. A motion control generates set points for the desired motion profile and sends controlling signals to the drive or amplifier, which in turn are amplified to analogue signals to the actuator under consideration.

In these systems there is a controller which co-ordinates between various moves and performs calculations for controlling various operations. There could be a master encoder or virtual axis sometimes working as a time master as well. Based on this master, various other slaves are controlled.

"The basic architecture of a motion control system consists of a motion controller that generates set points and closes a position and/or velocity feedback loop, an electrical drive that transforms the control signal from the motion controller into a higher power electrical current that is presented to the servo motor, etc. It would also include one or more feedback sensors such as optical encoder, resolver or 'Hall Effect' device to return the position of the motor to the motion controller in order to close the position and/or velocity control loops & mechanical components to transform the motion of the motor into the desired motion, including gears, shafting, ball screws, belts, etc. In case of direct drive technology no extra mechanical components are required," explains Thomas Wittek, executive director, Baumuller India Pvt Ltd.

Servomechanism: A unique system

Servomechanism is an integral part of motion control systems. A servomechanism, or servo is an automatic device that uses error-sensing feedback to correct the performance of a mechanism. The feedback or error-correction signals help control mechanical position and/or velocity of moving parts.

A servomechanism is unique among control systems in that it controls a parameter by commanding the time-based derivative of that parameter. For example, a servomechanism controlling position must be capable of changing the velocity of the system because the time-based derivative of position is velocity. A hydraulic actuator controlled by a spool valve and a position sensor is a good example because the velocity of the actuator is proportional to the error signal of the position sensor.

Servos are commonly electrical or partially electronic in nature, using an electric motor as the primary means of creating mechanical force. "Normally AC servo motors are used in most of the cases to control movements, but there can be other alternatives also depending upon the application requirements," explains Riyaz Shaikh, senior project manager, Warade Automation Solutions Pvt Ltd.

Other types of servos use hydraulics, pneumatics, or magnetic principles. Servos usually operate on the principle of negative feedback, where the control input is compared to the actual position

Courtesy: Baumuller

Riyaz Shaikh
senior project manager, Warade Automation Solutions Pvt Ltd

One can have various recipes in machines to control various production requirements. By merely feeding the parameters for a required recipe in the input interface, the system can be prepared to produce a new product.

of the mechanical system as measured by some sort of transducer at the output. Any difference between the actual and required values (an 'error signal') is amplified and used to drive the system in the direction necessary to reduce or eliminate the error.

Encoders

The purpose of employing a motion control system cannot be served without encoders. The position and velocity of moving parts can be controlled only when precise feedback of the movements is received at the input end. Encoders provide the feedback of movements and translate the information in the format required to adjust the input parameters.

"Encoders can be considered for motion control for machines with electrical axis. The type of machine and plastic component that is produced determines the requirement of an encoder for distance-length feedback. Linear encoders find immense applications in this area. Machines engaged in the production of plastic bags require encoders to define the size of the bag to be made," explains Thomas Kosthorst, plastic expert, Beckhoff Automation.

Myriad applications

Plastics processes can be classified into continuous processes like extrusion or batch processes like injection moulding and blow moulding. In addition, there are auxiliary or downstream equipment like winders, haul off or saws as well as material handling devices. These different processes and equipment employ different types of motion control.

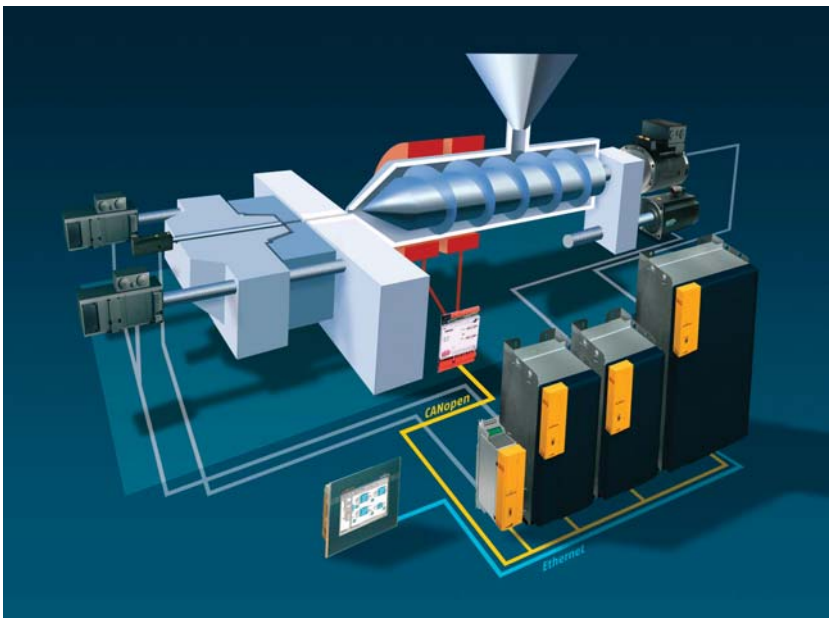
"The motion control systems employed in plastics processing encompasses different types of actuators like hydraulic actuators and/or electric actuators (frequency converter or servo amplifier type). The sensors that are integrated to provide feedback may vary from the simple limit switches to the more sophisticated proportional position sensors like resolver on incremental encoder and linear sensors like potentiometers or ultrasonic position sensors, mainly used for hydraulic axis," adds Kosthorst.

"Motion control systems are being widely employed for a variety of applications in the plastics processing arena. Some of them include multilayer sheet extrusion lines, fully automatic winders, tension controllers in web and in center/surface/gap winding, internal bubble cooling (IBC), PP thermoformer and vacuum thermoformers for producing XPS foam products," enumerates Sunil Jain, president, Rajoo Engineers. Compared to conventional sytems, motion control systems help in improving cost and energy efficiency. The elimination of wear-prone mechanical components in the system

Applications of motion control in plastics processing

- Extruder screw drives: Extrusion control, GSM control, layer ratio control
- Crammer auger drives
- Melt pump drives
- Air ring blowers in blown film extrusion lines
- Take off (nip) drives; web tension
- Winder drives; winding tension can be constant or can be varied as diameter of roll increases
- Thermoforming: Indexing sheet position under mould
- Thermoforming: Platen movements
- Thermoforming: Plug assist

Courtesy: Rajoo Engineers



Courtesy: Plastic Injection Moulding

Advantages of motion control systems over conventional systems

- Shorter cycle times because no waiting loops for limit switches
- Shorter cycle times because of perfect synchronisation with handling systems
- Shorter cycle times because of perfect adaption to hydraulic valves (linearisation)
- Better product quality due to precise switchover to holding pressure in injection presses
- Better product quality due to high sampling rate of parison controller in blow moulding machines
- Better product quality due to constant operating point after product change
- Better product quality due to elimination of errors depending on changes of hydraulic oil properties
- Less wear of moulds due to precise position control
- Less wear of moulds due to force controlled mould protection

Courtesy: Beckhoff Automation

Thomas Kosthorst
plastic expert, Beckhoff Automation

The sensors that are integrated to provide feedback can vary from the simple limit switches to the more sophisticated proportional position sensors like resolver on incremental encoder and linear sensors like potentiometers or ultrasonic position sensors.

significantly reduces friction losses in the system.

Key benefits

Motion control systems assist in reducing gauge variation in machine direction due to consistent screw rpm resulting in uniform flow. Fine adjustment in screw rpm can be done against analog speed pot through digital drives. The motor-life is enhanced and overtorque & undertorque controls protect the motor from overloads if the consistency of polymer mixture changes. Web tension control and winding tension control allows high take off speeds during extrusion and even during the subsequent converting process, thereby increasing productivity. Communication through HMI/MMI and connectivity with different sensors and measuring devices results in streamlining most of the operations. In thermoforming machines, the production can be enhanced through servo motors as they can be run with good accuracy at higher speeds.

"Today motion controlled drives and torque motors score well with a significantly better power density and an extended range of speeds ensure lower energy consumption. Motor rated torques up to 20,000 Nm and maximum torques up to 32,000 Nm are possible today. This opens up new application areas as well as significantly increases productivity in existing applications. When used as direct drives in extruders and injection moulding machines (eg, on the screw), they exhibit very high efficiency at the operating point. Thus, they enable an extremely efficient energy conversion since additional losses due to mechanical transmission elements are avoided," avers Wittek.

Courtesy: Baumuller

Meeting dynamics in demand

Motion control systems are flexible and help in meeting the dynamics in demand very quickly."One can have various recipes in machines to control various production requirements. By merely feeding the parameters for a required recipe in the input interface the system can be prepared to produce a new product. This makes product selection hassle free and at the same time automatically synchronises different machine and process operations," explains Shaikh. Synchronised movements of the machine or process helps reduce power jerks. Servos house inverter

Sunil Jain
president, Rajoo Engineers

Motion control systems are being widely used for a vareity of applications in the plastics processing arena. Some of them include multilayer sheet extrusion lines, fully automatic winders, tension controllers in web and in centre/surface/gap winding, among others.

technology at its core thereby imparting it with better power efficiency.

The cost advantage

Conventional machines are very bulky, consume more power and are difficult for product change-overs. It is a time-taking task to set the machine perfectly for a variety of products. One needs to have dedicated lines for the each product. "In case of injection moulding, the standard machinary available are hydraulic machines, which are inefficient and unsuitable for a competitive and dynamic market. By incorporating a motion control system, one can use position regulated screw on the injection unit and planetary roller screw drive positioning on the stamp. One can achieve 38-40 per cent of energy saving on an all-electric machine. Moreover cost of machine also reduces by 25 per cent with the same reproducibility," affirms Shaikh.

Recent advancements

Some of the latest advancements in motion control systems present tremendous opportunities to plastics processors. Further, due to the recent developments in these fundamental technologies, today processors can carry out operations with higher resolution and accuracy, and with much faster throughput than before. High-speed systems are now being used across the plastics processing industry. But these systems pose significant challenges as well. To determine the most appropriate solution that provides the best results for a given process, it is important to find the proper trade-off balance. Significant recent improvements include higher speeds, steeper acceleration and deceleration profiles, finer positional control, and faster convergence properties. Under the right circumstances, all of these factors can be used to achieve faster and more accurate point-to-point displacements and thus increase overall throughput.

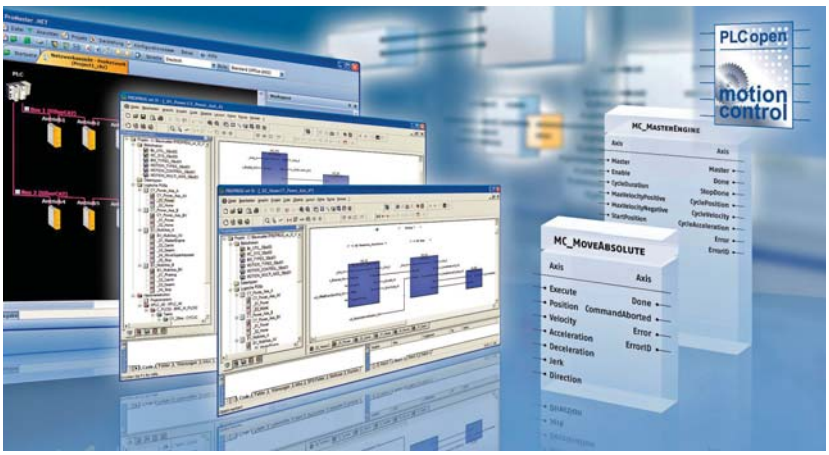
Special application macros are now available with the motion control systems to make programming easy. Some standards are also being generated for customisation of programming in niche areas. One such standard is PackML (Packaging Machine Language), which is increasingly becoming popular.

"The technology that was used in past to control the speed of AC/DC drive with the help of +/- 10VDC is slowly being replaced by high speed motion buses which are used for data transmission between the motion controller and programmable controller to realise optimum data passage. These motion buses are based primarily on optic fibre technology. Serial realtime communications system (SERCOS) is prominent of all the motion buses. Other popular buses are Profinet IRT and EtherCAT. Servo technology is improving day by day with use of faster processors and various DSP technology developments. Now-a-days the motion system can be easily hooked to the Internet and can have USB or wireless connectivity as the embedded technology, which is seeing an exponential growth," avers Shaikh.

The road ahead

Today motion control processor is largely a part of the servo drive itself. Inputs and outputs can be expanded over the bus. Servo motors are now available with in-built drive thereby making electrical cabinets compact resulting in space saving.

In order to keep up with the increased productivity of motion control systems and to deal with the much larger stream of data coming from the movement of several different parts, significant increases in processing power are required. Fortunately, computers and workstations have themselves been progressing steadily. But many recent performance improvements in computers and operating systems have come on the fronts of multiprocessor, multi-core and hyper-threading enhancements. To fully profit from recent performance improvements in motion control systems, classic algorithms need to be parallelised, optimised parallel algorithms need to be developed, and code and operations need to be made concurrent. MPP



Courtesy: Baumuller