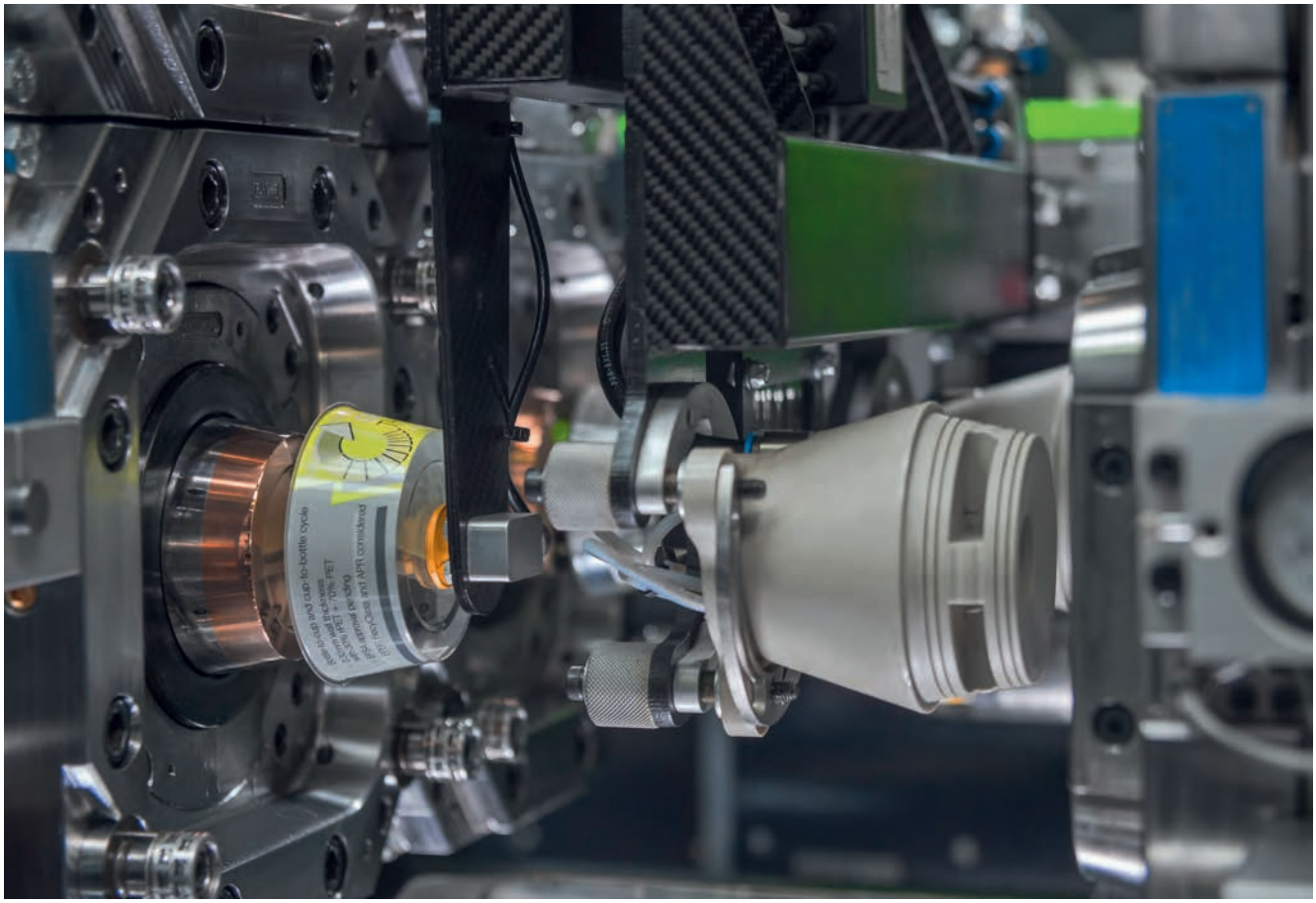
iQ motion control Shortens Cycle Times in High-Performance Injection Molding

How about a Little Bit Faster?

Cycle times of three to four seconds have long been part of everyday life in the injection molding of packaging parts. And the pressure to speed up production rhythms continues to increase. Shaving just one tenth of a second shorter off the cycle time is enough to increase output by three per cent. An assistance system from Engel is capable of doing precisely that, boosting the productivity of high-performance injection molding even further.



The pressure to work efficiently is huge, especially in the packaging industry. The production of thin-wall containers clearly shows the potential of iQ motion control to shorten cycle times. © Engel

The *iQ motion control* assistance system developed by Engel is able to automatically optimize the acceleration phases of movement sequences and thus make the movements faster. What is already possible for the Engel viper linear robots was also presented by the machine maker at K 2022 for mold movement. The packaging industry stands to benefit in particular because, in high-speed applications, the time taken by the injection molding machine to open and close the mold accounts for a significant portion of cycle time.

This is clearly demonstrated by the production of thin-wall containers in a 4-cavity mold on an Engel e-speed 280 injection molding machine (**Title figure**). The total cycle time is 3.15 s. Injection takes only 0.08 s and cooling just 0.8 s. Demolding of the parts thus takes 2.27 s, of which only 1.0 s can be attributed to removal by the robot. Mold movement therefore accounts for the remaining 1.27 s, or 40 % of the production time (**Fig. 1**).

Mold Movement Takes up a Large Share of Cycle Time

Engel e-speed injection molding machines are fitted with highly dynamic and efficient electric drives. These allow movement sequences to be performed in parallel, which is state of the art in the packaging industry.

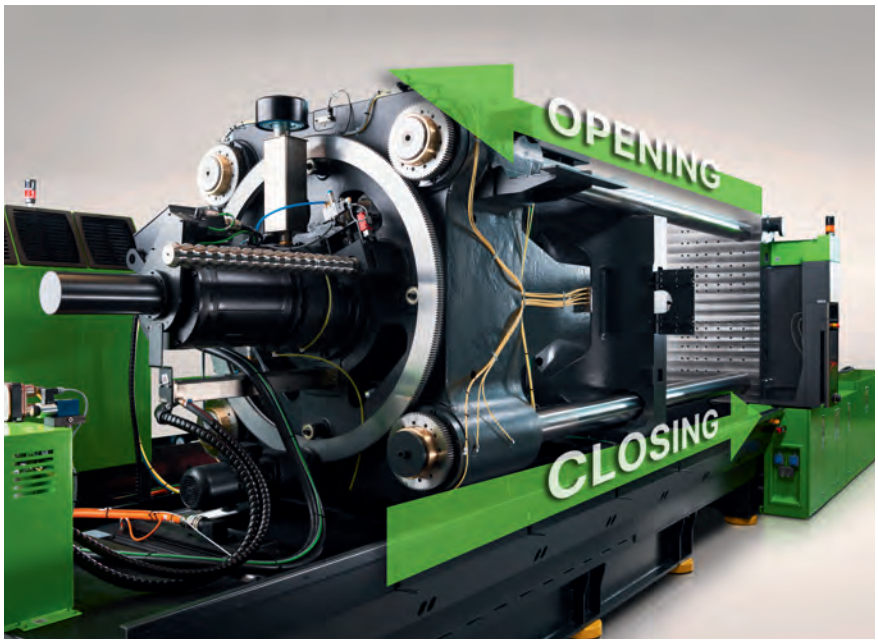


Fig. 1. iQ motion control shortens mold opening and closing on toggle machines. This leads to shorter dry cycle times. © Engel

In the production of thin-wall containers, for example, the clamping force is already reduced during cooling. Subsequent mold opening takes 0.5 s. Although the side-entry demolding robot can start executing the demolding movement just before the mold reaches the opening position, demolding itself does not start until the mold and robot movements have been completed.

For the fastest-possible removal, air valves push the parts with bursts of air onto the robot's vacuum gripper. The robot moves out of the mold's danger zone in a flash and the mold starts to close. Closing, including buildup of clamping force, takes 0.77 s. In order to minimize the cycle time, the injection process kicks in at 70 % of the set clamping force. An even earlier start is not possible, because the material might then flow into the mold parting line. But given that the injection time is just 0.08 s, the potential savings here are small anyway. Thus, no further time can be saved through parallel movements. To shorten the cycle time, the only other option is to further optimize the machine movements – such as that of the mold.

Precision Coordination of Mold Movement with the Process Is the Key

0.77 s for the closing movement is already nimble for a stroke of 285 mm, including clamping force buildup. All the while, the load on the drive is constantly changing: acceleration to ramp up the closing speed and deceleration to reduce it at the mold closing point; then acceleration again to build up the clamping force quickly and deceleration to complete the movement (**Fig. 2**). For reducing the movement time, the challenge now is knowing when to accelerate or decelerate and by how much. For, this depends on both the drive and the application, i.e. the mold, the stroke, the clamping force and other application-specific parameters.

That is precisely where *iQ motion control* comes in. This assistance system evaluates the aforementioned relationships in respect of the specific application and then calculates the optimum accelerations. This approach makes the best-possible use of the drive power, and shortens the time needed for mold movement by an average of 10 %.

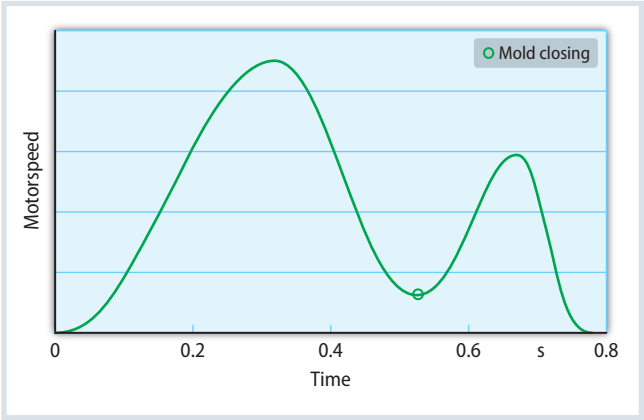


Fig. 2. During mold closing and subsequent dynamic buildup of clamping force, the drive is constantly cycling between acceleration and deceleration. Source: Engel; graphic: © Hanser

Focus on Mechatronic Drive System

To understand how *iQ motion control* works, it is necessary to take a closer look at the mechatronic drive system. The motor is connected to the toggle via a spindle, and this in turn is coupled to the moving platen and the mold. The toggle is the key element of the movement. Its variable transmission ratio ensures a high mold speed for long opening strokes (toggle retracted) and a high power transmission from motor to mold under clamping force (toggle extended) (**Fig. 3**).

However, the transmission ratio also changes the total inertia acting on the motor. With the toggle retracted, the mold weight is decisive, whereas it is barely noticeable at the mold closing point. For optimal drive operation, the acceleration must track the effective inertia in every position. And that is exactly what *iQ motion control* does. The assistance system uses the available drive torque, the relevant inertias and the clamping force to calculate the possible acceleration for each individual point, and connects these points into a motor movement.

This allows the machine to be operated dynamically and harmoniously, despite constantly changing conditions. This is not only evident from the drive torque: the outcome at the mold closing point is controlled braking and smooth closing of the mold halves. »

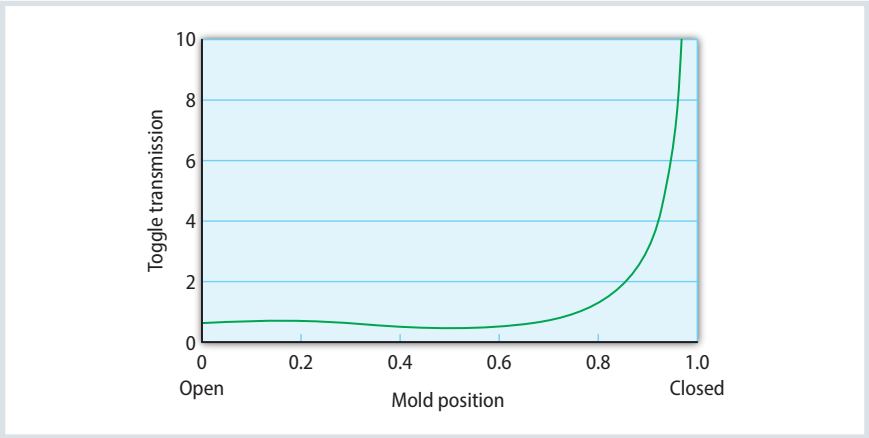


Fig. 3. The variable transmission ratio of the toggle ensures high mold speeds during long opening strokes (toggle retracted) and high power transmission from motor to mold under clamping force (toggle extended). Source: Engel; graphic: © Hanser

Fine-Tuning for Each Individual Application

The assistance system fine-tunes the mold movement for each individual application. The user benefits from shorter dry cycle times. In addition, operation of the machine is simplified.

At startup, the machine operator follows the usual procedure. He sets the opening stroke and the clamping force based on the specifications and his experience and – if this is desired for the application at hand – reduces the speed by adjusting the movement profile or the acceleration phases via the dynamic profile slider. The only new feature is that the operator can also input the weight of the moving mold halves. Where this is not known, an estimate based on mold size and steel density is sufficient. *iQ motion control* takes care of everything else. If a parameter of relevance to mold movement changes, the system recalculates the optimum movement in the shortest-possible time and transmits it to the drive for the first cycle.

The process can be started as usual, for example via the e-move operating element on the CC300 machine controller, and monitored as usual with *Auto Protect* to ensure the maximum-possible mold protection. Thus, as regards monitoring the machine, nothing has changed for the production worker and setting of the mold movement is easier than ever.

Producing Thin-Wall Containers Five Percent Faster

For the production of the thin-wall containers discussed earlier, *iQ motion control* helped to shorten the cycle time from 3.15 to 3.0 s. Expressed in terms of the dry cycle time, this is equivalent to a 12 % reduction – 1.12 s instead of 1.27 s. The defining of maximum values ensures that the machine does increase the load on the mechanics and the drive technology.

Comparison with the reference curve without *iQ motion control* makes it clear that the greatest potential for optimization lies in the first 0.3 to 0.5 s of the closing movement (**Fig. 4**). The greater drive torque already generates higher speeds at an earlier point in time, and that saves time. In addition, the torque is built up and released much more evenly – and that also saves time.

Standard Feature in High-Performance Machines

Such short movement times, as described in this example, can only be realized by adopting a mechatronic approach. Precision coordination of movement planning, drive control and mechanics is essential for enabling the existing components to perform to their maximum. Engel has recognized this potential and added *iQ motion control* to the standard scope of delivery for its high-performance e-speed (for packaging containers) and e-cap (for closures) machines. As a result, dry cycle times across the entire clamping force spectrum are reduced. And already today, both machines are the fastest on the market in their respective areas of application (*editor's note:* manufacturer's data).

In the future, Engel will also offer *iQ motion control* for retrofitting to e-cap and e-speed machines that have already

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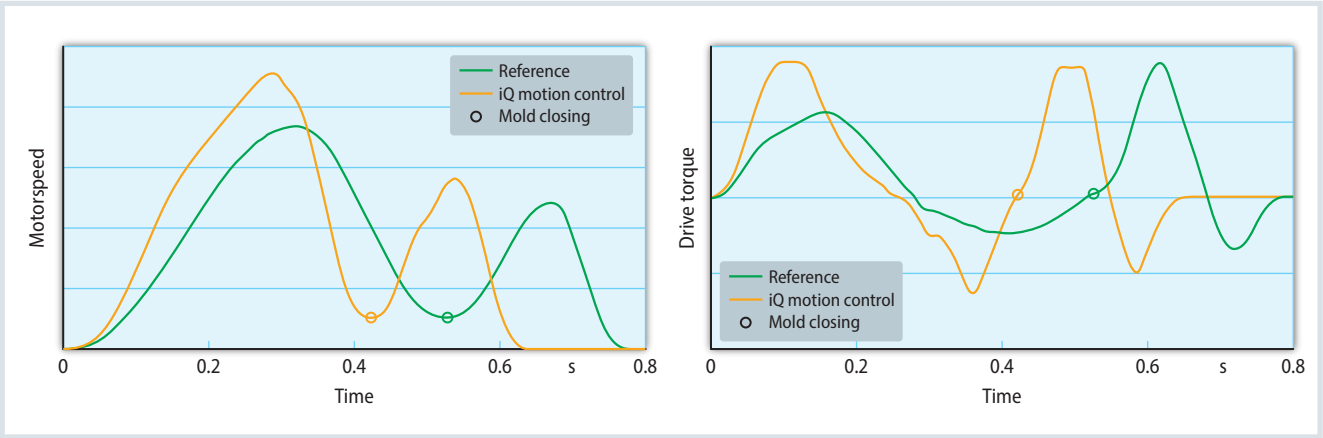

Fig. 4. The speed of the closing motor (left) and the drive torque (right) clearly reveal where time is saved in the cycle. The yellow curve shows the behavior obtained with active iQ motion control. Green shows the reference curve without iQ motion control. Source: Engel; graphic: © Hanser

been delivered. This is feasible because the assistance system does not require large connected loads, but merely makes better use of existing potential.

Conclusion

High-performance applications in the packaging industry are operated 24/7 and with extremely short cycle times – under growing pressure to boost efficiency. To generate even more output in this demanding field, Engel has developed an assistance system that optimizes the mold movement of high-performance machines for the application at hand. This means that each application can make full use of potential of its mechanics and drive technology. The outcome is an average 10 % reduction in dry cycle time and up to 5 % greater productivity. And all this is obtained without any additional effort on the part of the machine operator, because optimization is done automatically. ■