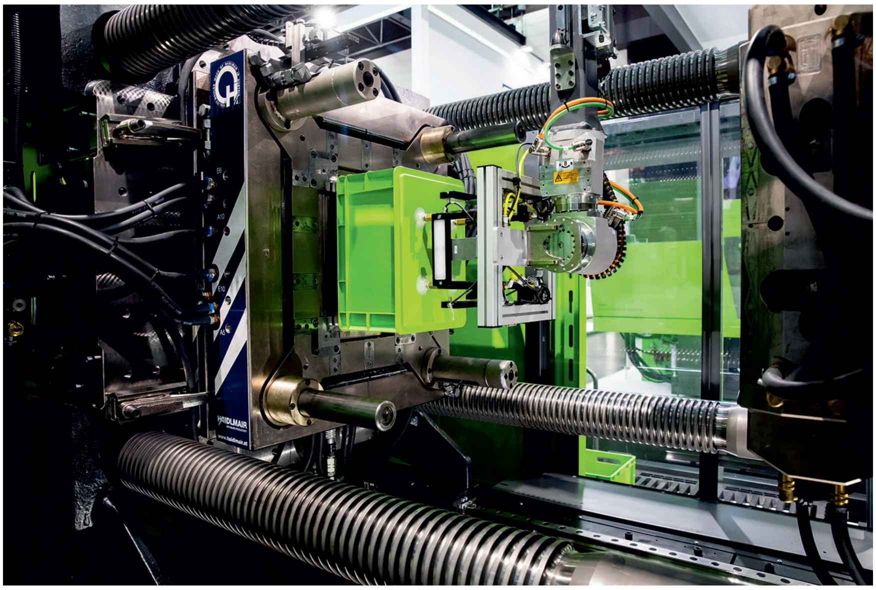
A Production Cell with Fluid Movements

iQ Motion Control Brings the Injection-Molding Machine and Robot Closer together

If the injection-molding machine and robot coordinate their movement sequences, this shortens the cycle time in many applications. iQ motion control from Engel now allows reliable early start combined with fully automatically optimized motion planning. The assistance system has been part of the standard kit of all new Engel viper-type linear robots since October 2021.



If the robot travels into the mold area already during the mold opening movement, this can shorten the cycle time. The effect is particularly large in the case of parts with long cores, such as boxes © Engel

Fluid movements arise when movements harmoniously intermesh. Only then are they economic and efficient. Every living organism masters this labor- and time-efficient interplay of different limbs – while, in this respect, a robot or automated machines and processes are only as good as the human being is at programming them via the system controls.

In an injection-molding cell, there are many different movable "limbs." Some of them critically also determine the cycle time of the injection molding process. They include the removal robot's entry and exit movements, as well as the mold opening and closing time. It is illuminating that much cycle time is wasted when a removal robot only starts moving when the injection mold is completely opened. To achieve fluid movements in the production cell, Engel Austria GmbH always focuses on the entire injection-molding cell and the interplay of the movements of injection-molding machine and robot. If Engel supplies the entire production cell, from the injection-molding machine, via the automation and other ancillaries, as far as the process engineering from a single source, all the components of the cell access the same control platform and the same database, and thereby have the best prerequisites for a short overall cycle time.

Since an injection-molding cell does not have command of these intermeshing parallel movements per se, the operator must specify the movements via the central control panel or the mobile handheld unit. He must teach-in the robot – specifying the path, velocity and acceleration of the insertion movement. The "iQ motion control" assistance system reduces this teaching effort to a few clicks.

Optimized Motion Planning Saves Cycle Time

Linear robots generally move from point to point. These individual points are specified during teaching. The plant operator determines the trajectory manually and specifies many points to optimize the paths (**Fig. 1**). In the iQ motion control feature, which has the new Engel viper series linear robot on board as standard, optimized motion planning was already implemented. The linear robot calculates its path and significantly fewer parameters therefore need to be set or positions taught. This significantly shortens the cycle time of the injection molding process as well as the setup time and the time required for teaching (**Fig. 2**).

iQ motion control is the latest product in Engel's range of intelligent assistance systems. To offer the greatest benefit for users, operation of the assistance systems must be very simple. iQ motion control, too, therefore has an intuitive dialog with all the available options for setting the removal (**Fig. 3**).

Optimized Motion Planning in Three Steps

To plan the robot motion during entry such that it reaches the removal position at precisely the point when the mold terminates its opening motion, certain background conditions must be taken into account: first the parameters set by the user, such as position and linear clearances, as well as the motion of the mold; on the other hand the robot-specific threshold values for velocity, acceleration and other parameters. Determining the optimum entry motion requires the following steps, which are processed automatically with the iQ motion control activated:

- Determine the optimum trajectory time: based on the last cycle, the time from reaching the set early-start position until mold opening is measured. This time period $t_{F,opt}$ corresponds to the robot's trajectory time, so that the robot and mold reach their respective end positions simultaneously.
- Calculate the shortest possible robot trajectory: the robot-specific kinematic limits (maximum velocity, maximum acceleration, etc.) of the individual axes and of the linear clearance defined by the operator can be used to calculate a robot trajectory. Here, the trajectory time $t_{R,opt}$ is the shortest possible trajectory time that can be achieved taking into account the particular boundary conditions. If the early start function is deactivated, this trajectory is used; the robot performs the insertion movement exploiting its limits.
- Scaling the trajectory: with the early start function activated, it should be ensured that the trajectory time of the robot motion $t_{R,opt}$ is greater than or equal to the determined optimum time $t_{F,opt}$. If this is the case anyway then, because of the robot's limits, it is not possible for it to reach the target position simultaneously with the mold. However, if $t_{R,opt} < t_{F,opt}$, the robot would approach the mold. To avoid this, the trajectory is scaled so that the condition $t_{R,opt} = t_{F,opt}$ is satisfied.

The function compensates for any long-term effects, such as differences in the running behavior of a cold and warm machine, temperature influences, etc.

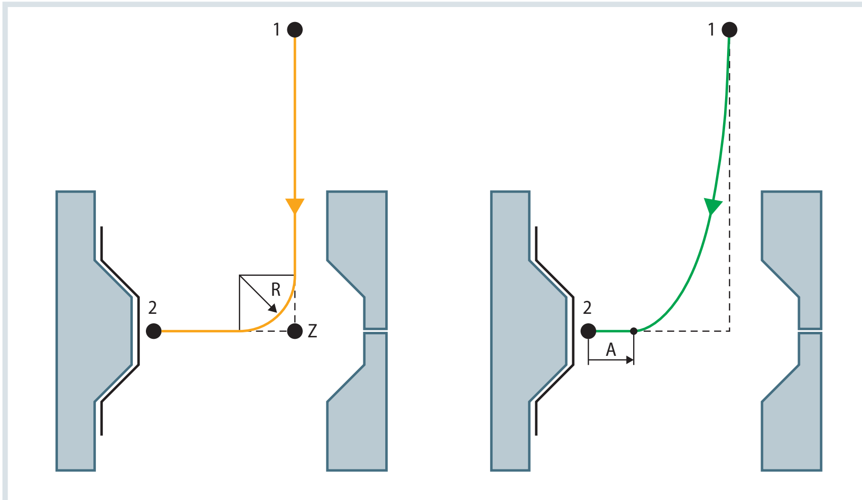


Fig. 1. iQ motion control operates with optimized motion planning (right). The path is computed as a whole and not generated by approximate positioning of single-axis movements Source: Engel; graphic: © Hanser

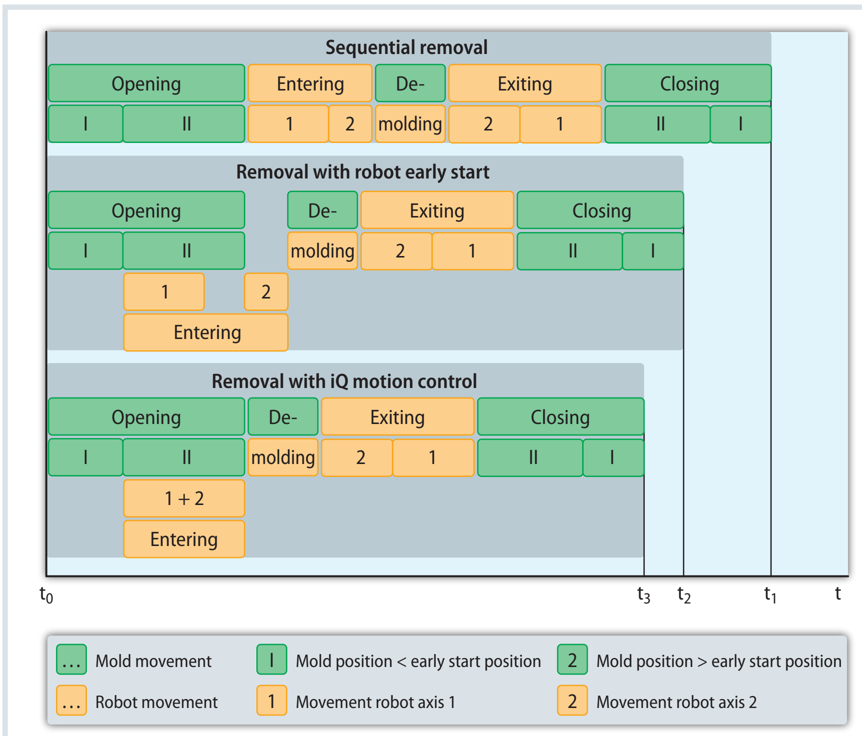


Fig. 2. The juxtaposition illustrates the high potential of iQ motion control for cycle time reduction Source: Engel; graphic: © Hanser

Early Start Desired and Supported

In modern systems, the cycle time is also unnecessarily prolonged if, while opening, the mold has to wait for the robot to enter into the removal area and demold the parts. Since, thanks to the integrated control system, the robot in an Engel injection-molding cell has direct access to the machine data, such as mold opening stroke and position of the moving platen, the robot and machine execute a co-ordinated movement and, ideally, are at the removal position and mold-open position respectively at the same time for removal. In this case, the cycle is not prolonged by entry of the robot.

The cycle time is shortened with the aid of the iQ motion control, since the mold does not have to wait for the robot. This is achieved by the fact that the robot does not have to wait for the complete mold opening stroke during entering but can enter into the machine area at an early stage due to the already familiar "early start" feature, which is completely integrated in the software.

The settings dialog displays a suggestion for the early start position, which is based on the robot and machine setting parameters. This allows even less experienced machine operators to efficiently and reliably leverage the advantages of the assistance system.

Multistage Reliability through Intensive Data Exchange

Despite the early entry into the machine area, a collision between the robot and moving mold half can be ruled out »

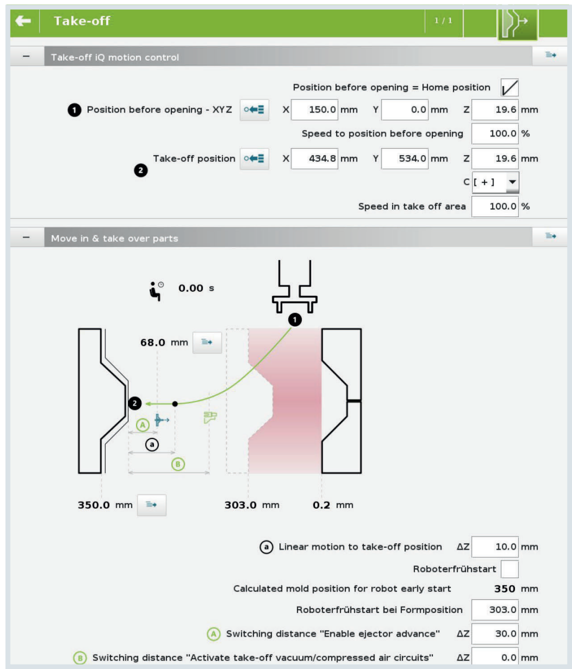


Fig. 3. Intuitive user guidance is a prerequisite for the acceptance and success of intelligent assistance systems © Engel

Avoiding Vibrations

Due to the protruding kinematics, linear robots systemically tend to vibrate. Thanks to iQ vibration control, the intelligent motions in robots of the Engel viper series prevent undesirable deflections. Waiting times at the end of the motion are therefore no longer required. iQ motion control goes a step further. By the fact that smooth fourfold-constant motions do not excite vibrations, there is no loss in cycle time due to the compensation of large vibrations (**Fig. 6**).

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with certainty, since iQ motion control operates with a two-stage safety net. The first stage corrects the robot movement at an early stage in the event of identified deviations from the planned mold movement. The second stage ensures that the robot can brake in good time before contact with the mold in the event of an exception situation or an emergency stop.

Since the robot knows the exact position of the movable mounting plate, it consequently also stops if such a collision threatens. In this way, damage to the mold and gripper system due to unforeseen incorrect positions or faulty settings can be reliably avoided thanks to the direct data exchange within the common control system of the integrated system solution.

Who Benefits from This?

Even processes with simple removal movements can be very readily optimized by iQ motion control. Users producing deep injection molded parts – for example housing components, boxes or containers with a long core (**Title figure**) benefit particularly greatly, since the machine must execute a particularly large mold opening stroke.

To exploit the potential, Engel has performed tests with a viper 12 linear robot. With a mold-opening stroke of 490 mm and a maximum velocity of the movable mold mounting plate of 1465 mm/s, an

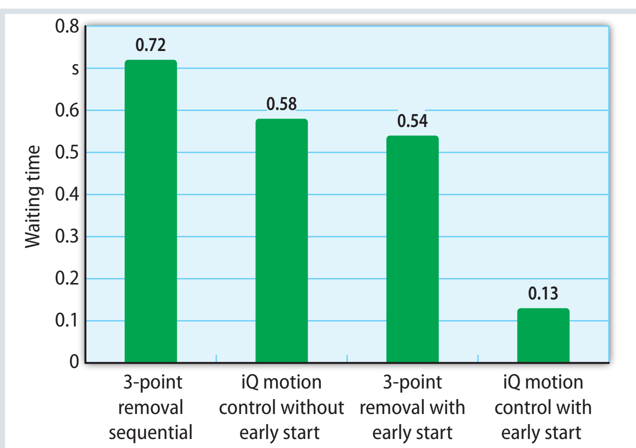

Fig. 4. The trials confirm the greatly reduced waiting time with iQ motion control and early start Source: Engel; graphic: © Hanser

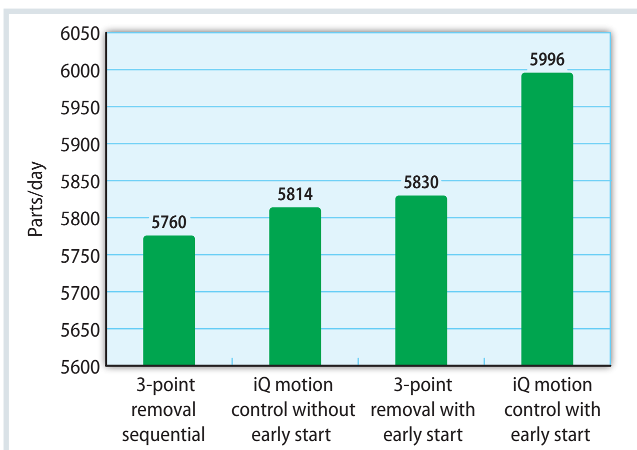

Fig. 5. The reduced cycle time leads to a significantly higher output Source: Engel; graphic: © Hanser

overall cycle time of 15 s was achieved. The robot early start was at mold position 303 mm. A greatly shortened waiting time was found (**Fig. 4**).

The waiting time means the time that elapses between the completion of the mold motion and the end of the phase during which the gripper enters into the mold space. It directly forms part of the cycle time because the mold is blocked by the robot during this time span. With an overall cycle time of 15 s, for an assumed continuous operation of 24 h, with iQ motion control and with early start, 236 more parts per cavity can be produced per day than with sequential three-point removal (**Fig. 5**).

The use of iQ motion control is independent of the injection-molding machine type and the type of removal. The assistance system automatically adapts to the respective removal variant. This comprises both vertical and – in the case of tie-barless machines – horizontal removal for the known construction variants, as well as deposition at the operator side, non-operator side and at the end side in the case of longitudinal constructions.

This feature will not remain the only one targeted at an even closer interplay between the machine and robot. However, iQ motion control is Engel's first assistance system comprising the machine-robot. ■

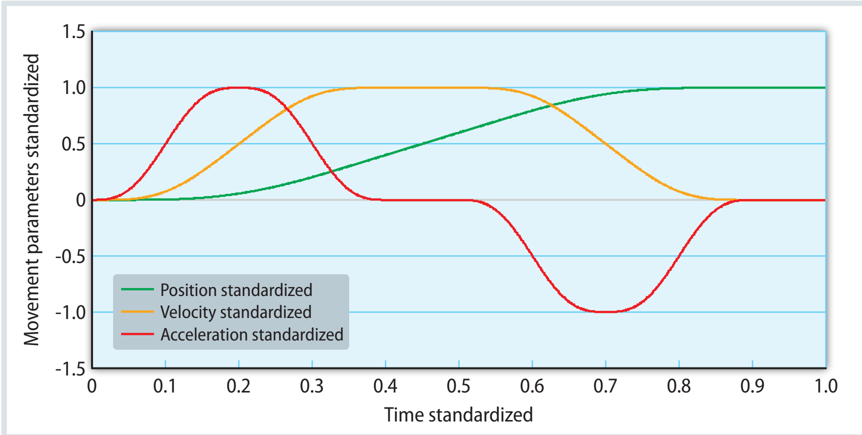

Fig. 6. Examples of smooth movement profiles of robot axes. Vibrations of the robot axes can also prolong the cycle time Source: Engel; graphic: © Hanser

Feature	Effect	Benefit
Optimized motion planning for the linear robot	Fewer parameters or positions must be taught; the motion is calculated intelligently.	Time saving during teaching as well as cycle time saving due to better planning of the motion.
Robot can directly access machine data thanks to control integration	The robot and machine perform coordinated movements and are ideally at the correct position for removal at the same time.	Cycle-time saving – waiting times of mold or robot are eliminated.
Multistage safety equipment	The robot stops promptly if a crash threatens, since it knows the exact position of the movable mounting plate.	Improved machine safety due to avoidance of mold and end-of-arm tool damage.
Joint data management of machine and robot	During mold exchange, part data only need to be loaded once.	Avoidance of faults and time saving during set-up.
Clear, graphic-aided setting dialogs	The operator only has to specify a few parameters himself and is supported by graphics.	Time saving during teaching due to intuitive presentation.

Table 1. Facts about iQ motion control Source: Engel

Sustainable Colorant and Additive Masterbatches

100 Percent Made from Recycling Material

Avient presents colorant and additive masterbatches with recycled post-consumer materials matrix.

Achieving 100 % post-consumer recycled packaging is at the forefront of the sustainability goals for many consumer goods companies. Avient 's Rejoin PCR masterbatch enables recycled post-consumer materials (PCR) to be used as a carrier resin, effectively allowing a bottle or part to be manufactured with 100 % PCR.

As stated in a press release, it combines pigments and functional additives into one solution without creating a negative impact on color or mechanical properties. Rejoin can be added at the press using standard equipment and having little to no impact on processing.

Until now, masterbatch has generally been made using virgin material as a carrier resin. This means reportedly that at typical let-down ratios, the finished product would contain 3 to 5 % non-recycled plastic. With major consumer goods companies actively defining sustainability goals of 100 % PCR polyolefin packaging, Avient has responded by developing Rejoin PCR masterbatch in customizable colors and special effects.

Especially for packaging, post-consumer recycled percentages of 100 % are increasingly in demand © Avient

To the product presentation:
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