All-Electric Efficiency – The New Standard for Thin-Wall Injection Moulding?

30% reduction in energy costs with all-electric high-performance injection moulding machines

Rising production costs combined with low margins are placing increasing pressure on manufacturers of plastic packaging. High production efficiency has therefore become more than ever an economic necessity. The newly developed, highly dynamic and powerful electric injection units from ENGEL open up new potential for resource-efficient thin-wall injection moulding.

The sharp increase in material and electricity prices in recent years has posed a particular challenge for injection moulders in the packaging industry. The already low margins on products such as yoghurt cups and margarine tubs have been significantly reduced by substantially higher variable costs, in some cases falling below the profitability threshold. Due to long-term supply agreements and intense market competition, passing these costs on through higher sales prices is often not feasible. Reducing manufacturing costs is therefore frequently the only way to maintain profitable production.
Two primary levers are available:

- Reduction of material consumption through thinner wall sections
- Reduction of energy consumption of the injection moulding system

However, reducing wall thickness generally requires higher machine performance due to increased flow length-to-wall thickness ratios, which traditionally conflicts with lower energy consumption requirements. Higher injection performance typically results in increased energy demand and has historically limited the use of highly efficient all-electric injection moulding machines.

ENGEL has intensively developed electric high-performance injection units and now presents a solution that enables optimum utilisation of both levers within a single machine concept. The new electric PREMIUM injection units *(Fig. 1)* for the e-motion series achieve performance levels approaching those of accumulator-driven hydraulic systems while combining

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them with the efficiency and precision of servo-electric drives *(Fig. 2).* Using two practical application examples, ENGEL demonstrates the significant potential this technology offers for manufacturers of thin-wall packaging.

All-Electric High-Performance Injection Moulding Machine e-motion with PAC Package
The e-motion series is the most powerful all-electric machine range in the ENGEL portfolio. Thanks to its high-performance drive technology, it offers exceptionally short dry-cycle times and high material throughput rates at low energy consumption. For the two application examples described below, an e-motion machine with 2,800 kN clamping force and the new electric PREMIUM injection unit in size 765 was selected. In addition, the injection moulding machine was equipped with the optional PAC package in order to meet the high performance demands and extreme load conditions associated with demanding thin-wall injection moulding applications.

Application Example 1: 1.3 L Dairy Pail
As part of Fakuma 2023, ENGEL presented this application for the first time on an all-electric e-motion 765/280 T equipped with the PAC package. The two-cavity mould for the 1.3 L pail *(Fig. 3, 4)* was supplied by mould maker Inmold and optimised for minimum wall thickness in order to reduce material consumption. The wall thickness of only 0.45 mm results in an exceptionally low part weight of just 26.7 g and a flow length-to-wall thickness ratio exceeding 400:1.

A particular challenge during the injection phase is the complex geometry at the end of flow path, featuring numerous reinforcing ribs as well as two tamper-evident seals with predetermined breaking points *(Fig. 5).* Production using injection-compression moulding is therefore not feasible; precise and reliable cavity filling must be ensured solely by the performance capability of the injection unit.

The process data of this application demonstrates the significant potential of the all-electric machine concept for thin-wall injection moulding: At a cycle time of just 4.5 seconds, the pails, including in-mould labelling, were produced with a stable and robust process under continuous production conditions. Optical quality inspection confirmed consistently accurate filling of both cavities throughout the entire production run. In terms of output rate and part

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quality, no compromises were identified compared with hybrid or hydraulic machine concepts.

A significant advantage, however, was observed in energy consumption: the total energy demand of the production system was reduced by approximately 30% solely through the use of electric injection technology compared with a comparable hybrid machine. This cost advantage has a direct positive impact on operating margins and therefore represents a substantial competitive advantage for manufacturers of thin-wall packaging. For production sites in countries with CO_2 taxation schemes, the resulting reduction in carbon footprint provides an additional opportunity for cost savings.

Process Parameters – 1.3 L Dairy Pail – e-motion 765/280 T	
Wall thickness	0.45 mm
Flow length/wall thickness Ratio	>400:1
Screw Diameter	50 mm
Injection time	0.17 s
Injection Speed	600 mm/s
Cycle time	4.5 s
Energy consumption	0.37 kWh/kg
Energy cost reduction*	€19,840 per year

*Calculation basis: electricity price of €0.20/kWh, 7,200 operating hours, and the energy consumption of a modern hybrid machine with hydraulic accumulator used as the reference benchmark.

Application Example 2: Plant Pot – Virgin Material and Recyclate

Plant pots represent another example of a thin-wall injection moulded component manufactured in very high volumes at the lowest possible unit costs. In contrast to food packaging applications such as the example described above, recycled polypropylene can also be processed without any issues in this application *(Fig. 6)*. Extensive trial series conducted on both hybrid and all-electric machines provided a comprehensive database for a technically sound comparison of the two machine concepts using both virgin material and recyclate. The plant pot features a progressively decreasing wall thickness from the base to the upper rim, averaging 0.39 mm *(Fig. 8),* and a flow length-to-wall thickness ratio of 260:1. With a

part weight of 7.2 g, the six-cavity mould results in a total shot weight of 43.2 g. The injection moulding trials were likewise carried out on an all-electric e-motion 765/280 T equipped with the PAC package and compared with previous trials performed on hybrid injection moulding machines.

The results were convincing: compared with hybrid injection moulding machines, production on the all-electric e-motion proved possible at identical cycle times and with equivalent part quality – regardless of whether virgin material or recyclate was processed. A slightly longer injection time, resulting from the lower maximum injection speed of the electric injection unit, was compensated for by initiating injection slightly earlier during the clamping force build-up phase.

While no differences could be identified between hybrid and all-electric machine concepts in terms of process stability and product quality, a significant difference was observed in the energy consumption measurements: the energy demand of the all-electric e-motion was 33.7% lower than that of a comparable hybrid machine.

Process Parameters – Plant Pot – e-motion 765/280 T	
Wall thickness	0.39 mm
Flow length-to-wall thickness Ratio	260:1
Screw Diameter	50 mm
Injection time	0.14 s
Injection Speed	600 mm/s
Cycle time	1.9 s
Specific energy consumption	0.37 kWh/kg
Energy cost savings*	€22,756 per year

Calculation basis: Electricity price €0.20/kWh, 7,200 operating hours, with the energy consumption of a state-of-the-art hybrid injection moulding machine used as the reference baseline.

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Further Savings Potential through Digital Assistance Programs
In addition to the approximately one-third lower energy demand of the all-electric e-motion series, two digital assistance systems from ENGEL provide further potential for cost reduction for manufacturers of thin-wall packaging applications:

iQ motion control optimises the acceleration profile of the toggle-type clamping unit and enables up to 12% shorter dry cycle times. The optimal motion trajectory of the moving platen is automatically calculated, taking into account the mould opening stroke, clamping force, and tool weight. The software fully exploits the machine's and drive technology's inherent performance potential without increasing mechanical loads or energy consumption.

iQ weight control compares the injection pressure curve of each cycle with a previously defined reference curve and compensates for external process influences by automatically adjusting the shot volume and switchover point for the subsequent cycle. In this way, part weight can be kept constant despite variations in material viscosity, making it a valuable and well-established tool for processing regrind materials.

For packaging applications, however, an additional benefit arises: due to significantly reduced part weight variation, the shot weight can be set closer to the lower tolerance limit of the component while simultaneously reducing the scrap rate. This enables reduced material consumption alongside a higher proportion of good parts, with particularly strong effects in high-volume production. Using the plant pot as an example: a reduction in part weight of 0.2 g enables, with 6 cavities, an assumed 6,800 production hours per year, and a cycle time of 1.9 s, annual material cost savings of over €10,000 (based on an assumed average material price of €0.83/kg PP).

All-Electric Efficiency – the New Standard in Thin-Wall Injection Moulding
The two practical examples demonstrate that the application range for all-electric machines in thin-wall injection moulding has expanded significantly and now also includes components with very high performance requirements. When converting from hybrid to all-electric machines, a reduction in energy consumption of approximately one third can be expected while maintaining consistent process stability and part quality.

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ENGEL therefore recommends selecting all-electric machines as the baseline when designing new production systems for thin-wall applications. For customer trials, all-electric injection moulding machines are permanently available at the ENGEL Packaging Centre *(Fig. 9).*

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Bilder

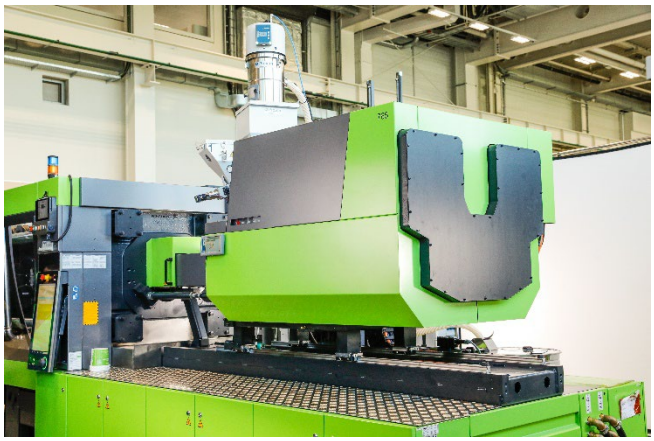

Fig. 1: The new all-electric high-performance injection units from ENGEL significantly expand the application range of electric injection moulding machines for thin-wall injection moulding.

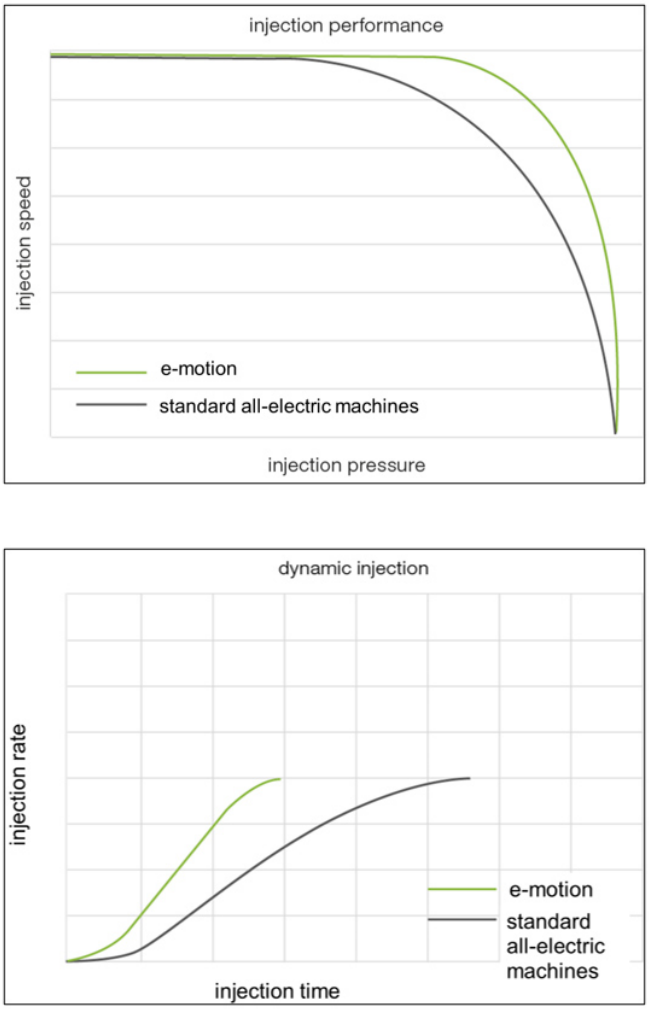

Fig. 2: The new high-dynamic PREMIUM injection units from ENGEL Austria GmbH achieve higher injection speeds at elevated injection pressures over almost the entire injection phase.

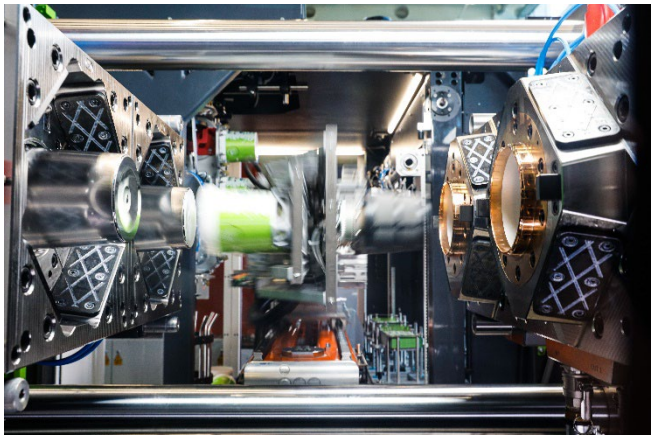

Fig. 3: The mould for the 1.3 L pail mounted on an all-electric e-motion 765/280 T injection moulding machine.

Fig. 4: The 1.3 L pail is characterised by a reduced part weight of only 26.7 g.

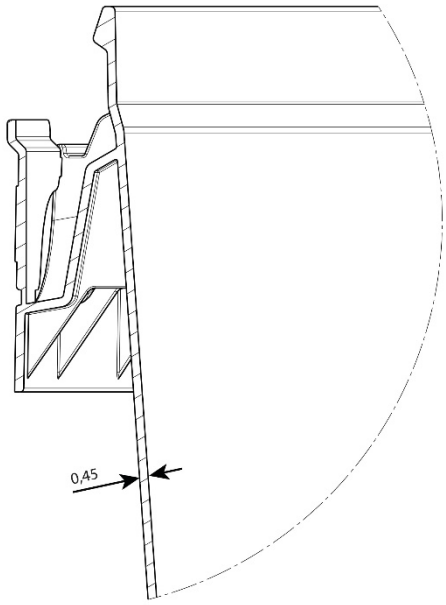

Fig. 5: Detailed view of the complex geometry of the pail in the sealing edge area.
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Fig. 6: Plant pot made from virgin material and recyclate.
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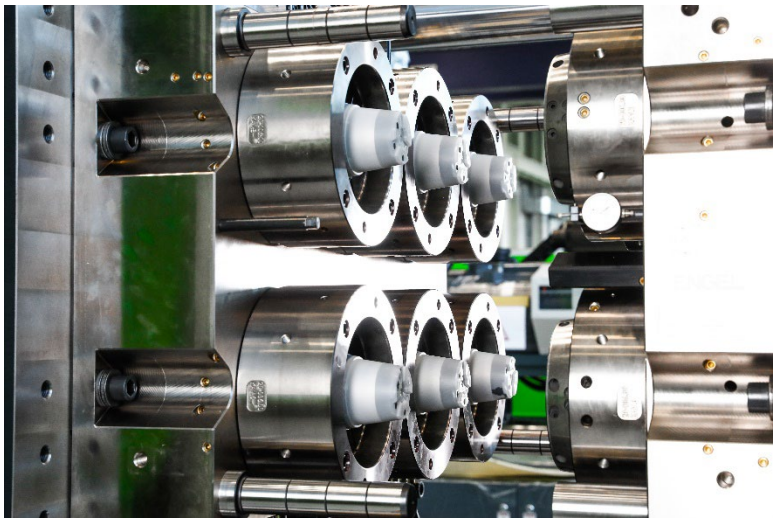

Fig. 7: Glaroform 6-cavity plant pot mould mounted on an all-electric e-motion 765/280 T injection moulding machine.

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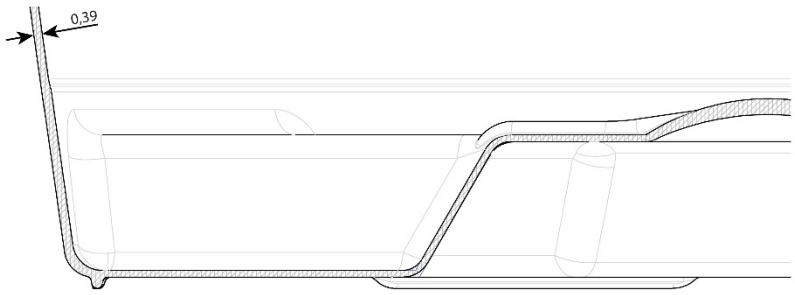

Fig. 8: Detailed view of the plant pot in the base area.

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Fig. 9: Several injection moulding machines are permanently available for customer trials at the ENGEL Packaging Center.