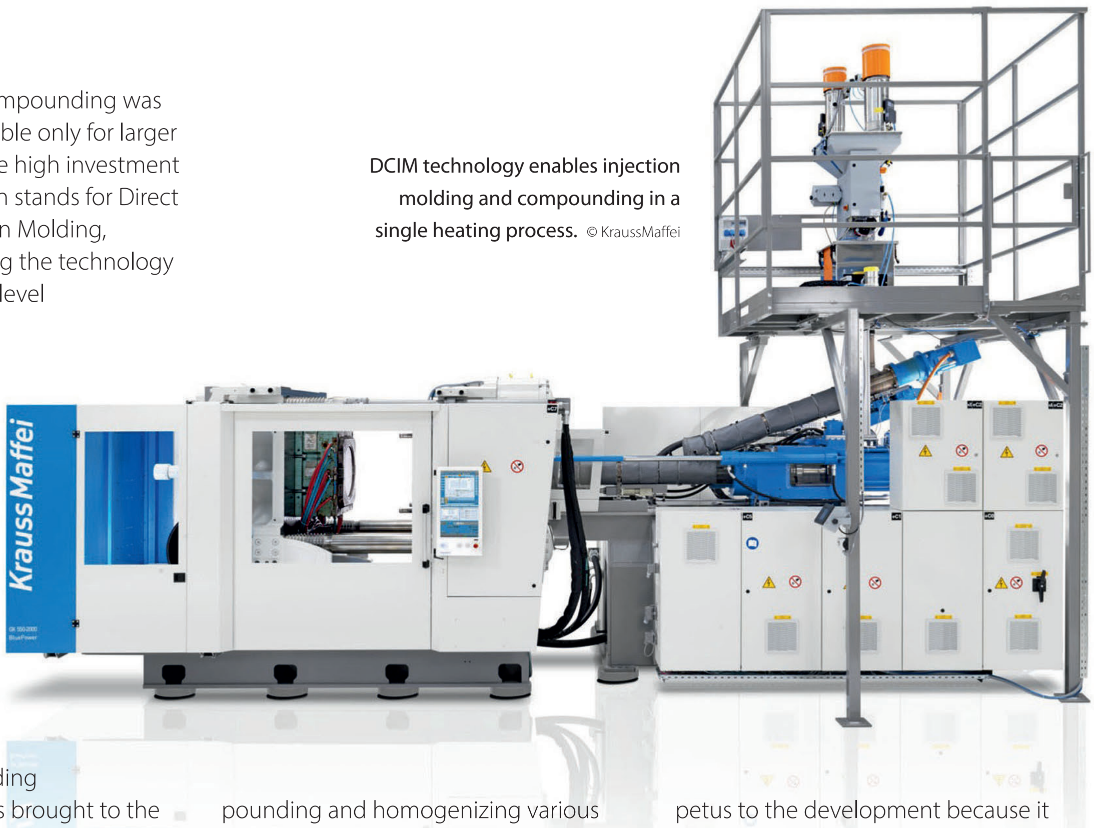
Efficiency Meets Sustainability: Systematically Reduce Costs and CO_2 Emissions

Cost-Effective Direct Compounding for Medium-Sized Components

Plastics processors are under a twofold pressure today: first, the material and energy prices are rising. Second, they have to find solutions to reduce the CO_2 footprint of their production. Customers and legislators are requiring this in increasing measure. Direct compounding, which means manufacturing and processing compounds in a one-step process, opens up new potential here – now also for smaller components with a further development from KraussMaffei.



DCIM technology enables injection molding and compounding in a single heating process. © KraussMaffei

Until now, direct compounding was economically feasible only for larger components due to the high investment costs. With DCIM, which stands for Direct Compounding Injection Molding, KraussMaffei is elevating the technology to a new performance level now so that even articles weighing 50 g or more can be produced more efficiently and cost-effectively. The major benefit is the material cost savings that the user achieves with this.

Over 20 years of experience in direct compounding with the injection molding compounder (IMC) was brought to the development of the DCIM technology. For the IMC, which KraussMaffei presented in the year 2000, an extruder was integrated into the injection molding process for the first time [1]. Due to the high investment costs, however, the twin-screw extruder used here requires products with a shot weight of 1.5 kg or more to be economically attractive. DCIM now combines a single-screw extruder and the injection molding machine, thereby offering an alternative for small to medium-sized components (**Title figure**).

The new concept pursues the same goal as IMC technology, namely, compounding and homogenizing various materials directly on the injection molding machine to produce an injection molded part with significant cost savings and comparable product quality. The process combines cost benefits and process advantages. The difference lies in the preparation of the material mixture.

The reason for the change to a single-screw extruder is simple: For small to medium throughputs, a single-screw extruder is already very well suited for blending polymers and for mixing in additives, reinforcing or charging a mold. By combining the product segments of extrusion and injection molding under one roof, KraussMaffei gave crucial impetus to the development because it was possible to utilize their combined expertise (**Fig. 1**).

Production in a Single Heating Process Conserves Energy and Cuts Costs

The single-screw extruder feeds the melt directly into the injection unit. Both produce products intermittently. This turns compounding and injection molding into a single-sequence process – one that involves a single heating process. This reduces CO_2 emissions (due to the overall lower energy consumption), decreases the labor for storage and transportation, and above all also decreases the costs for special compound formulations (**Fig. 2**). The range of applications for DCIM is diverse. It extends from simple glass-fiber compounds and polymer blends (such as ABS/PC) to use of additives, modification and combinations of the aforementioned. Other application fields include highly viscous polyofelin melts from recycling processes and upcycling of recyclates or agglomerates (**Fig. 3**).

Finally, DCIM offers processors the option of determining the cost-efficiency of their materials at their own discretion as well as of tailoring the materials exactly to the application. That way the expertise for the formulation and the responsibility for the material quality also pass on to the processor.

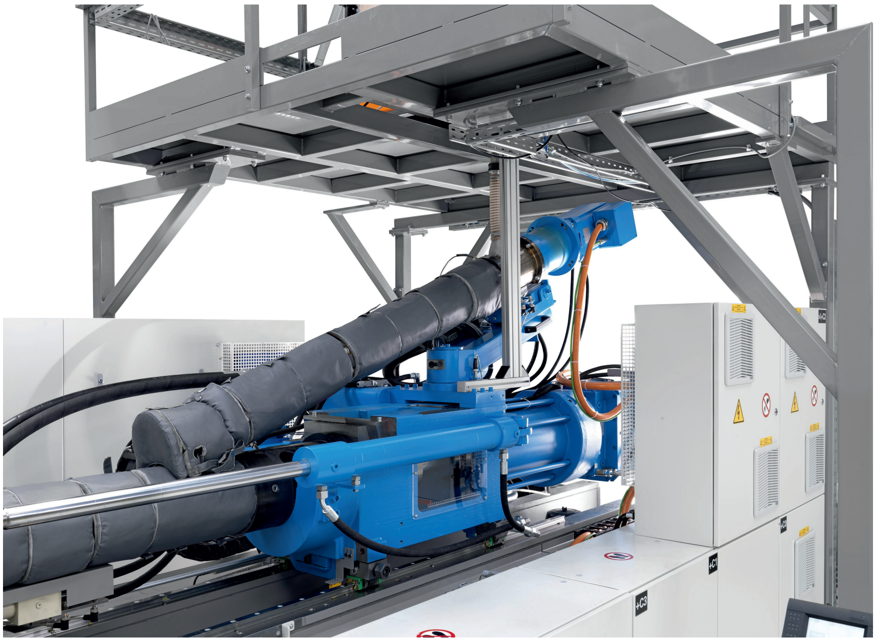


Fig. 1. In the DCIM process, a single-screw extruder connected directly to the plasticizing unit does the compounding. © KraussMaffei

Shot Weights from 50 to 2000 g

The DCIM series is offered for a clamping force range from 1600 to 11,000 kN and thereby supports the Injection Molding Compounder (IMC) with a shot weight range of about 50 to 2000 g (based on natural PP). When the single-screw extruder was integrated into the injection molding machine, special attention was given to creating a compact and simultaneously user-friendly system. That is why the extruder is easy to access and maintain, being installed in a piggyback position on a standard injection unit (**Fig. 1**). This configuration additionally provides yet another important freedom, namely, that the system can also be operated as a standard machine. It only takes a few minutes to make the change, and this makes the concept extremely flexible.

KraussMaffei's hydraulic two-platen clamping unit is compact, fast and low-maintenance. It is engineered to minimize mold wear and to ensure a high degree of platen parallelism. The clamping system attached behind the moving clamping platen allows for easy »

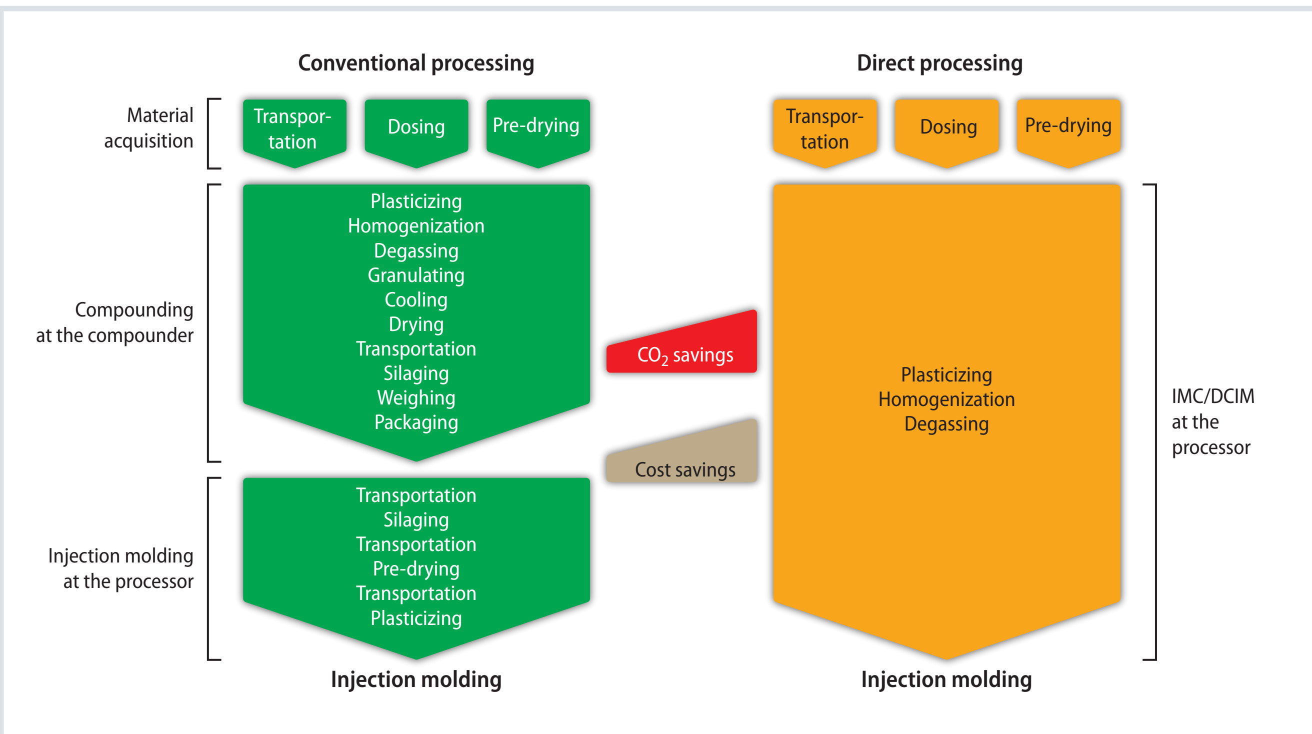


Fig. 2. Having fewer process steps in the direct process improves the CO_2 balance of the components and reduces the material costs by 0.30 to 1.00 EUR/kg. Source: KraussMaffei; graphic: © Hanser

movement in the ejector area during setup and configuration work. The two-platen clamp also makes it easy to implement special processes or meet special requirements. The good accessibility in the clamping area is particularly suitable for integration of automation solutions.

ROI in Less than One Year

The article costs of injection molded parts are significantly governed by the material expenses. Depending on the application, the percentage amounts to 40 to 70 % (**Fig. 4**). In the case of traditional injection molding, the processor can have only little to no influence at all on this percentage. The DCIM process tackles precisely this point and creates additional freedom: With this system, processors are now able to also influence the component costs by means of the material price. Particularly in the small and medium-sized machine segment, technical compounds are processed very frequently. Most applications use plastic types that have been refined at least once, which is reflected in the price of the material.

Aside from its suitability from a process technology standpoint, a single-screw extruder is more cost-effective to manufacture than a twin-screw extruder as it is used for large components in the IMC. As a result, the additional costs turn out to be lower for small systems and the system is profitable after only a short period of use (less than one year, in relation to the surcharge for a standard injection molding machine). The first systems are already on the market – on the one hand for research purposes at institutes, on the other hand in the industrial environment for producing series parts in the automotive and packaging industries.

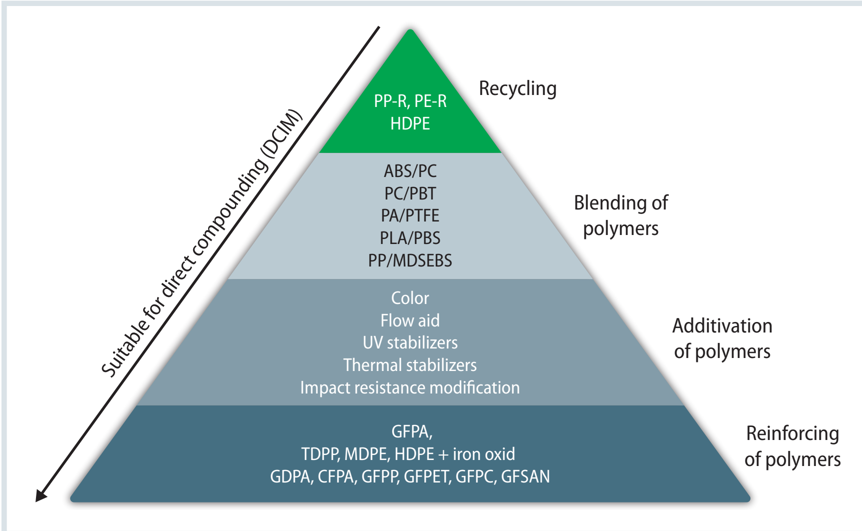


Fig. 3. The DCIM process allows for customized, cost-effective material mixtures. It is best suited for reinforcing polymers. Source: KraussMaffei; graphic: © Hanser

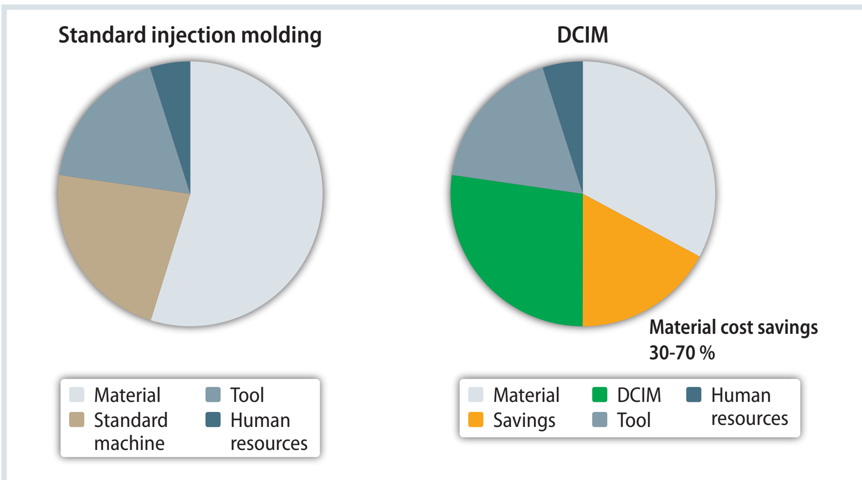


Fig. 4. DCIM reduces the manufacturing costs of technical injection molded parts compared to the standard injection molding process by 30 to 70 %. Source: KraussMaffei; graphic: © Hanser

The Last Degree of Freedom Still Lacking

The IMC has been at home in these industries for a long time already. It will continue to exist in the large clamping force and shot weight range and carry on the more than 20-year history of direct compounding at KraussMaffei.

KraussMaffei set a technical milestone back when extrusion and injection molding were combined in one machine for the first time. This was implemented in a system that compounds polypropylene with continuous glass fibers so that this mixture could then be processed into a front-end module for the automotive industry [2]. Applications such as this – as well as recycled material processing, addition of mineral or renewable fillers and polymer blend compounding – laid the cornerstone for the enduring success story.

More than half of the installed systems are used for the production of large components in the automotive industry.

Info

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The trade show application described above can be seen in **Hall C15, booth C24-D24**

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Fig. 5. Sustainable transport packaging: at K 2022, a GX 1100–4300 DCIM produces rugged reusable crates made of three different recycled materials. © KraussMaffei

Door modules, acoustic insulation systems, infotainment panels, front ends, underbody covers and much more are manufactured. Furthermore, IMC systems are used in the logistics industry for the production of pallets and tubs as well as for large technical pats of various applications. The material costs can be substantially reduced by the upstream process of twin-screw extrusion. However, the additional equipment requires corresponding investments, so using IMC technology does not make sense economically until the shot weights are higher.

The conversion of injection molding from simple, mechanical open/close machines to high-performance, highly technical, networked and smart systems has long since taken place and is now being completed by the last degree of freedom still lacking: designing polymer material based on your own ideas.

Directly Compounding Recycled Materials of Various Viscosities

At the K 2022 plastics trade show, KraussMaffei is presenting a type GX 1100–4300 DCIM machine. It will process three different recycled materials that come from industrial waste:

- PP from staple fibers (MFR 800–1000 g/10 min. @ 230 °C/2.16 kg).
- Shredded HDPE goods from the logistics and packaging industry (MFR 5–15 g/10 min. @ 190 °C/2.16 kg).
- HDPE blow molding goods from toy production (MFR < 1 g/10 min. @ 190 °C/2.16 kg).

These inhomogeneous raw materials, whose viscosities vary from tough as chewing gum to a watery consistency, are reliably and efficiently processed into a new material with the DCIM process. Further additives, such as stabilizers, color additives and micaceous iron oxide for shortening the cooling times and thus also the cycle times, can also be reliably incorporated. At the trade show booth, these are turned into rugged five-piece reusable collapsible crates, such as those used for transporting fresh fish, in a cycle time of 35 s (**Fig. 5**).

For the particularly price-driven packaging and logistics industry, DCIM opens up the attractive option of saving up to 50 % of material costs. The shot weight of the reusable collapsible crate is 1000 g, and the external production of a compound alone would cost as much as 0.6 EUR/kg on average.

Conclusion

This application serves as an example with which KraussMaffei shows the opportunities and advantages that the DCIM process offers processors: individual freedom for creating the material and its properties, reliable processing of recycled materials, energy-efficient production and cost reduction for the material as well as the expertise and control over their own formulation development. ■