Injection Compression Molding of Down-Gauged Packaging Applications

Thinner Packaging Items without Loss of Quality

Increasingly strict environmental regulations require thin-wall packaging applications, which can provide both material and weight savings. However, this has been taking injection molding to its limits, whereas injection compression molding promises further wall thickness reductions. In a joint application center for thin-wall packaging, companies Sabic and Netstal have optimized the materials, equipment and process of the technology.

Real progress needs collaboration between partners. This is particularly evident in the field of packaging, where conventional injection molding has reached its limits in terms of reducing the wall thicknesses of applications. Advanced thin-wall technology must provide both: material and energy savings as well as uncompromising mechanical performance and aesthetics.

At the Thin-wall Packaging Application Center in Näfels, Switzerland, plastics supplier Sabic and injection machines manufacturer Netstal have bundled their strengths in complementary material and processing expertise to transfer the technology of injection compression molding (ICM) to the thin-wall packaging market. This opens significant opportunities for further down-gauging and lightweighting at lower injection pressures, reduced clamp forces and shorter cycle times. It also meets with increasing regulatory, brand owner and consumer demands for packaging solutions that reduce waste while offering very high product safety, appealing aesthetics as well as circularity potential and economics.

Diversity of Materials Complicates Transfer

Although injection compression molding has been a common technology e.g. in automotive and optical applications, its translation to thin-wall packaging is challenging because of the differences in material types, mold and machine setups to address the vast diversity of applications and part geometries in packaging. Some examples are pails for food and non-food items as well as containers for dairy, meat, vegetable, chilled and frozen products that all require a highly customized and integrated approach.

Materials typically used in these segments are PP homopolymers, random copolymers and impact copolymers in high melt flow ranges of MFR 50 (g/10 min) and up. The material development for ICM applications focuses on eliminating this constraint in viscosities, while also enabling the use of polymers with MFR 20 or lower.

Beyond materials, the injection molding machine plays a vital role, as it must ensure a fast, reliable and repeatable process with intuitive and safe operation. The aXos Control of Netstal machines allows for a guided and swift setup of process parameters, which is key to implementing cost-efficient ICM solutions for thin-wall packaging. To further optimize the process, the partners also invested in an injection molding tool for research purposes that holds design features typical of thin-wall applications and enables variable wall thicknesses. In-mold sensors at different locations are used to assess ICM versus standard injection molding needs. This integrated approach has resulted in material, equipment and design guidelines targeted at maximizing the down-gauging and weight-saving potential of ICM molded packaging applications.

The thin-wall packaging application space is dominated by very high flow length to wall thickness ratios. There is a trend to further increase this ratio up to 1:350 and above, but this exceeds the limits of standard injection molding or reduces the mechanical performance of the packaging applications. In contrast, the ICM technology provides ways to achieve further wall thickness reductions or accommodate longer flow paths by taking advantage of the compression stroke (**Fig. 1**).

Compared to standard injection molding, a compression step is added to the molding cycle, which enables further down-gauging and weight saving for thin-wall packaging applications. The tool is equipped with a special compression frame that allows the injection sequence to start when »

	Netstal injection compression molding process	Standard injection molding process
Machine type and size	Elion 4200	Elios 5500
Required clamp force	3800 kN	5000 kN
Part weight	7.50 g	9.00 g
Weight reduction	16.7 %	
Material savings	144 t/a	

Table. Clamp force, weight and material savings potential of an injection compression molded lid with a 8+8 stack mold. Source: Netstal

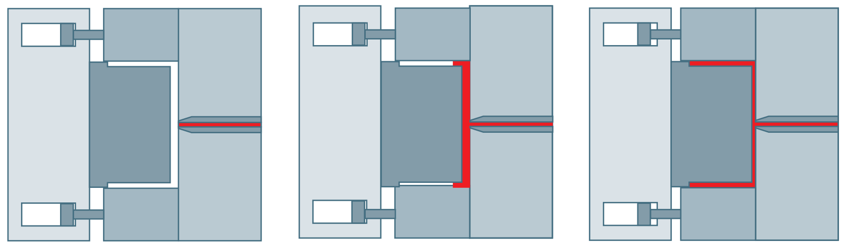

Fig. 1. Injection compression molding sequence from left: 1) mold still slightly opened (compression gap); 2) melt begins to fill the cavity, while the clamp performs another compression stroke to fully close the mold; 3) filling completed. Source: Sabic; graphic © Hanser

the tool is still slightly opened. This is the so-called compression gap. The melt then begins to fill the cavity, while in parallel – on a timed basis – a compression stroke is made to close the gap and fill the part completely. The additional compression step does not create any additional cycle time.

Weight Savings up to 30 %

Trials at the Thin-wall Packaging Application Center in Näfels, have demonstrated significant benefits when this process is combined with proper materials, optimized mold and application design. In the case of a drinking cup for airline onboard catering, it was found that the injection pressure can be decreased by up to 50 % as compared to injection molding, resulting in a potential wall thickness and weight reduction of 20 %.

Looking at the differences with some more detail, the wall thickness of the cup when using standard injection molding could be minimized to 0.35 mm, whereas the ICM process opened a further down-gauging potential to 0.28 mm. The standard injection molded cup weighs 6.5 g, the injection compression molded cup weighs 5.2 g. A difference of 1.3 g may not figure so much when a drink is served, but – in terms of material consumption when manufacturing the airline cup – the weight reduction adds up to savings of 40 t per year with a 4-cavity mold. Additional improvements included higher top load and impact resistance as well as the possibility of using materials with a lower MFR (**Fig. 2**).

Netstal had already presented a first industrial implementation of its ICM technology during Fakuma 2015, running a 4+4 stack mold for margarine tubs at the show. The advantages of the technology – lower clamp force requirements (smaller machine), weight savings of 20 % and increased lifespan of mold – still hold true today. Thanks to further developments in materials and process control, the wall thickness

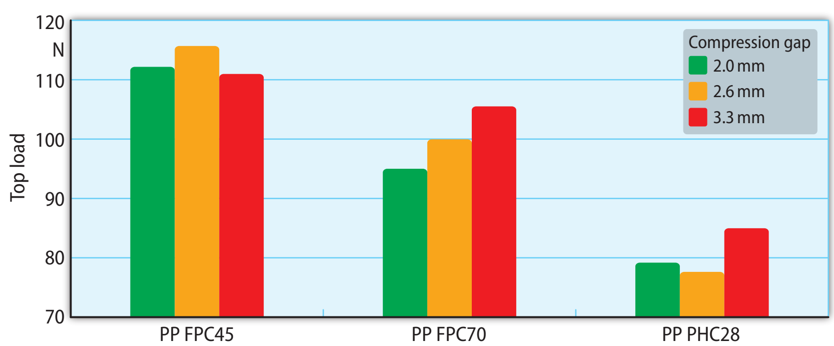

Fig. 2. Top load and fill performance with different materials at specific compression gap settings: depending on the material, the size of the compression gap results in different load-bearing capacities. Source: Sabic; graphic © Hanser

Info

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Service

For further information:
www.sabic.com
www.netstal.com

Both companies will showcase the technology at K 2022:
Sabic: Hall 6, booth D42
Netstal: Hall 15, booth D24

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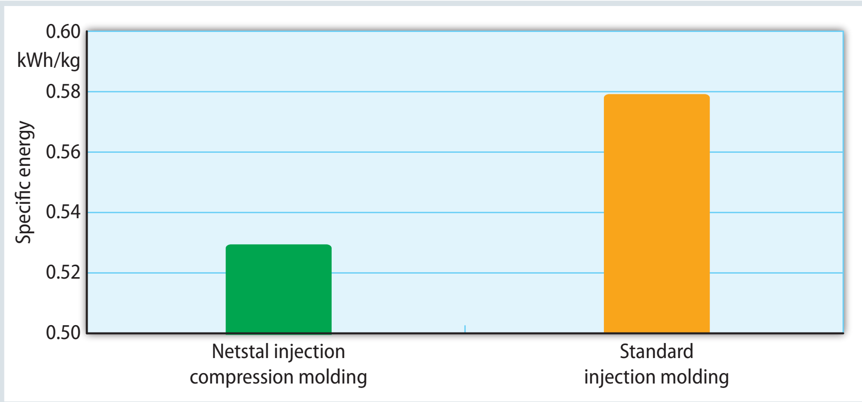

Fig. 3. Injection compression molding offers a high energy savings potential vs. standard injection molding. Source: Sabic; graphic © Hanser

can even be reduced by up to 30 %, and the possibility of using a smaller machine also offers significant energy savings (**Fig. 3**).

The **Table** summarizes the clamp force, weight and material savings potential for an ICM lid application manufactured in an 8+8 stack mold. Apart from the more obvious advantages of lower injection pressure and reduced weight, the technology also resulted in lower molded-in stress, thus minimizing warpage and enabling a flatter lid, which is considered an important quality feature.

The collaboration has already allowed Netstal to introduce new machine and process control features. These are already available for packaging customers and molders and address control requirements for utilizing the maximum potential of the ICM technology.

For proper ICM process parameter settings, users need functions which are normally not available in the controls of conventional injection molding machines. In its aXos Control system, Netstal provides several screens for selecting and setting ICM specific parameters, such as the required clamp force. (**Fig. 4**).

Injection molding machines are normally designed to apply and maintain uniform clamp and locking forces when the mold is closed. The ICM process has a slightly different mold closing sequence (**Fig. 1**), which called for customized control functions. Therefore, a special production mode (in the aXos Control adapts to the requirements of the ICM process in the background. The modified control regime allows machine users to increase the compression speed by up to 30 %.

Critical Process Values and Safety

In addition, a newly developed timing diagram (**Fig. 5**) helps users visualize critical process values of freely selectable parameters in order to determine the best possible settings in their particular application process. Amongst others, the feature permits to control the fill performance of a part depending on the material and the compression gap. In a process without ICM, it would not be possible to fill the part using e.g. the PP FPC45 material within the injection pressure limits of the machine.

Another newly developed control feature addresses the process safety for ICM. The safety strategies incorporated in the standard control of injection molding machines will not suffice if the machine is set to run an ICM process, since there is no function available to monitor the force at the compression gap. The mold protection in Netstal's ICM control system monitors the force at the compression gap until the compression phase is completed, which means that trapped parts will be safely detected by the machine.

Injection compression molding offers an enormous potential for weight, material, energy and cost saving thin-wall applications. The collaboration of Sabic and Netstal has demonstrated that the transfer of this technology to thin-wall packaging can be effectively accelerated when value chain partners bundle their strengths to deliver optimized material, machine and process control solutions. ■

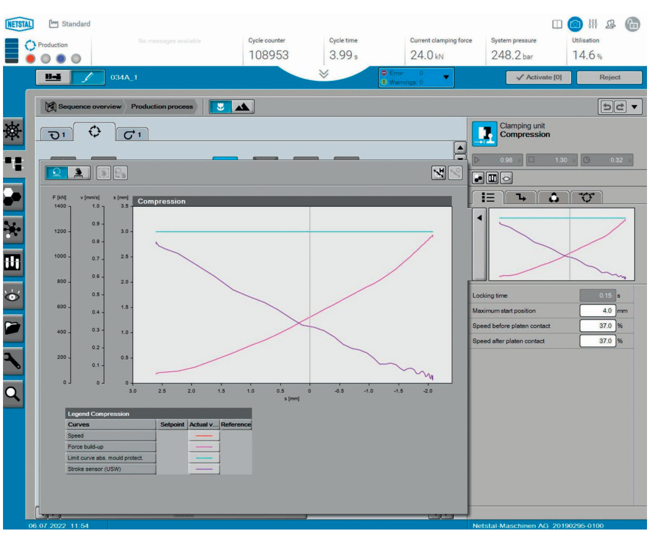

Fig. 4. Netstal has added special screens to the aXos Control of its injection molding machines for setting injection compression molding parameters such as the clamp force. © Netstal

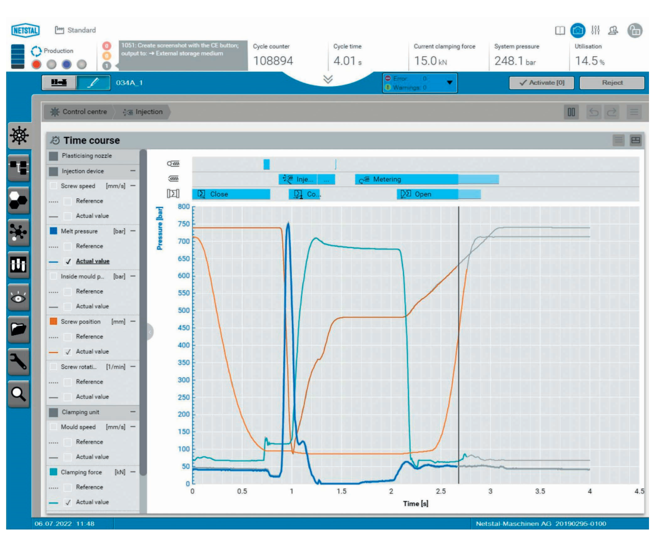

Fig. 5. Timing screen function to visualize critical process parameters and determining the optimum injection compression molding parameter settings. © Netstal