

Redesigning the closure for circularity

Injection moulders of caps and closures are now required to find solutions for a much wider range of problems, including the use of tethered caps and post-consumer recyclate. Mark Holmes finds more



Caps and closures have always required excellent functionality and shelf appeal for brand owners. However, sustainability and the needs of the plastics circular economy are providing new challenges for injection moulders, resin suppliers and manufacturers of injection moulding machines. As well as continued lightweighting, these now include more easily recyclable materials, increased use of post-consumer recyclate and tethered closures.

There are a number of significant market trends emerging at present for the injection moulding of caps and closures, reports **Husky**. "Firstly, there is health and safety," says Michael White, Business Manager for Closures. "By default, the existing neck and closure design needs to ensure a hygienic drinking experience from first opening until the package is deposited in the recycling collection box. In addition, there are increased lightweighting and legislative efforts that are designed to improve the sustainability of existing finishes and caps, for example, tethered closure legislation that requires the closure to remain on the bottle. Creating a premium product is also a factor, for example, tall and larger neck finish variants that provide a more

pleasant opening experience. For commodity-type applications (for example, large case formats), the industry requires ultra-lightweight finishes to maximise production cost savings."

The need for tethering has led to a fundamental redesign of the closure. "The challenges are numerous," says White. "For example, a functional hinge needs to be incorporated that is robust and can achieve more than 30 openings and re-closings. In addition, the hinge must be intuitive to operate and have positive shell opening, locking and re-closing functions. It also needs to feature audible and tactile cues to signal when the shell is in the locked position. Additionally, the closure still needs to perform all of its typical functions of sealing, tampering evidence and carbonation retention. Weight neutrality is another

design constraint while featuring a tether system that must be able to withstand greater than 25N pull force."

Husky has developed a range of solutions that address this tethered need.

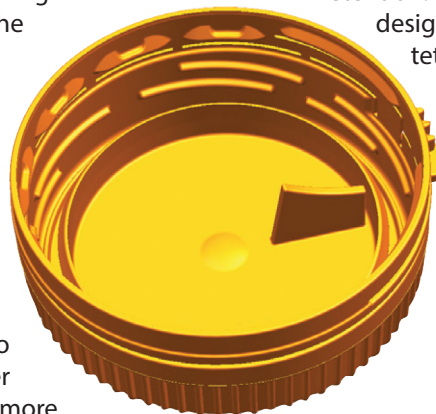
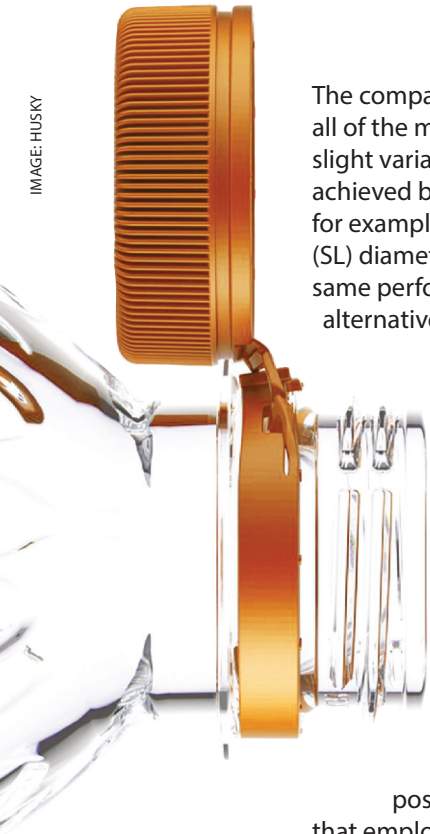


IMAGE: HUSKY

Left: Husky has designed a re-closure feature for caps



Above: The 1881 Large Diameter (33mm) Support Ledge tethered cap developed by Husky

The company says that they are compatible with all of the most popular neck finishes and have slight variations in terms of how shell locking is achieved based on neck specific requirements, for example, small versus large support ledge (SL) diameters. All of the designs feature the same performance criteria as the non-tethered alternative.

Examples of new designs include the 1881 Large Diameter Support Ledge. This is for large SL diameters (33mm), with a closure locking feature that leverages the support ledge to assist in the shell locking position. The 1881 Small Diameter Support Ledge is for small SL diameters (31mm) and has a closure locking feature that leverages a hook defined on the shell in cooperation with a flap defined in the tamper evident band to achieve a positive locking position.

There is also a re-closing feature that employs an integrated cam to promote an intuitive, repeatable and smooth re-closing experience. Husky adds that it is working with a variety of recognisable global brands to offer solutions that incorporate these features to satisfy their specific product needs.

There are also a number of future opportunities that the company sees for caps and closures. "There are a number of priorities that Husky is focusing on in terms of development," White says. "Improvements will be focused primarily in a number of key areas. In terms of sustainability, there will be continued efforts around tethering, lightweighting and increasing the post-consumer resin (PCR) content to ensure that Husky's closure offerings offer the best environmental footprint possible. In performance, Husky's closure developments will continue to offer elevated performance levels without compromising safety, sustainability or user experience. There is also a need for enhanced safety. The global coronavirus pandemic has emphasised the importance of supplying a dispensing system that offers a hygienic drinking solution for the consumer. We will continue to seek alternative options to make tamper evidence more visible without adding weight or compromising performance. Finally, for shelf differentiation and usability, we will continue to develop designs that offer brands a means further differentiate themselves on the shelf and incorporate that enhance the consumer experience." Caps moulders have also

been responding to the EU's Single Use Plastics Directive's requirement for closures to remain tethered to the bottle during consumption. For their customers in the beverage industry, the new closures must not affect the cost of production, bottle design, bottle neck, filling line or the capper. In addition, the closures should be available both as lightweight press-on caps, which are mainly used in non-pressurised bottles such as still water, and as screw-on caps for higher demands on the tightness of the closure.

Bericap has achieved this through a redesign of existing closures. "Within the product development process, it quickly became clear that the screw caps had to be redesigned no matter which technical solution is proposed," says Volker Spiesmacher, Director Head of Product Sales and Marketing. "The tether requires more space in the area of the tamper evidence band. Hence, the screw caps had to be redesigned."

The four technical proposals for screw caps now presented by Bericap can be applied to the same closure shell which is a redesign of the current closure. All proposals can be applied to all major neck finishes available on the market. However, some proposals perform better, if small details of the neck are modified. The Bericap proposals allow for a market introduction of the new closure design suitable for tethered caps at an earlier stage.

Therefore, the redesigned caps can be readily manufactured with all technical pre-requisites for a tethered version set in place when they become mandatory in 2024. The redesigned caps can then be introduced at a time that is in line with customers' marketing activities. In addition to the screw-cap solutions, Bericap also offers press-on caps for standard necks as well as a premium solution with customised neck finish which offers the highest weight savings on neck and closure.

Bericap has also developed a filling aid for AdBlue tanks in diesel cars. It allows car owners to fill their AdBlue containers easier and faster, and helps to comply with current emissions standards.

Since 2015, all first-registered Euro 6 diesel vehicles have had to use the AdBlue additive to reduce nitrogen oxide emissions.

The filling aid from Bericap simplifies the handling of common 10 l refuelling tanks considerably, which in turn saves time on the road. In addition, Bericap has developed two weight-optimised closures that can be used both for AdBlue and for

Right: Bericap has developed a new tethered cap



Right: Closure Systems International has introduced the 38mm D-KL liner-less HDPE closure for dairy applications

commercially available car care products Bericap offers various shapes and sizes of expandable pourer types, which provide significant pouring assistance to the consumer, for example, when bridging a necessary distance for spill free pouring. They can be used for container sizes from 5-25 l. The foldable pourers are designed for easy push-in application into containers. They fit onto containers with standard neck sizes DIN42 and DIN45 due to their conical foot design – they are simply pressed into the container neck and start pouring leak-free. For accurate pouring results the long expandable nozzle is bendable 180 degrees and will remain in this position without additional fixing by hand. This feature allows the consumer to hold the container with both hands for safe pouring. The flow is fast and steady without leakage. The pourers are available with and without shrink foil, which can protect against dust when necessary. The Bericap foldable pourers are already used by notable customers from the automotive, mineral oil and chemical industry.

Berry Bramlage, part of Berry Global, has also developed a tethered closure design that meets the EU requirements. The company says that it has developed a series of designs for all types of neck finishes, including both screw and snap-on. The solutions involve additional strands or tabs on the tamper-evident band that keep the closure attached after opening and enable easy reclosing of the bottle. In order to maximise consumer convenience and ease of use, different options for the docking of the closure once the bottle has been opened are available to meet different product or pack requirements. These include placing the closure beneath the neck (the Lasso and V-Tethered closures) or adjacent to it at a wide angle (Compact Flip and Proxima closures).



IMAGE: CSI

The two-piece SecureSnap closure for snap-on necks is based on the flip top design of Berry Bramlage's Secure Flip sports cap, with its opening tamper-evident band that is retained on the closure after opening. All closures can be specified in a variety of colours with a choice of decoration options for enhanced branding and on-shelf appeal.

Closure Systems International (CSI) has introduced the 38mm D-KL liner-less HDPE closure (38D-KL), which is designed with consumers and dairy product applications in mind. With improved application performance and drop-down tamper evidence for additional security, the company says that the 38D-KL is engineered to deliver reliable performance on HDPE and PET dairy bottles. The 38D-KL is commercially available for applications in non-carbonated cold- and ambient-filled beverages and liquid dairy markets.

CSI adds that the 38D-KL closure offers a sustainable solution and can be sourced with up to 40% PolyCycle PCR HDPE resin. PolyCycle PCR is sourced from recycled milk and other beverage containers, providing an opportunity for closed loop packaging and ensuring the high quality sourcing. Both the HDPE and the PolyCycle PCR version of the 38D-KL closure are 100% recyclable.

Engel has introduced the next generation of the all-electric E-cap injection moulding machine series for beverage caps. The company says that production of 29/25 lightweight caps on a new E-cap 380 machine combines short cycle times with high precision and low energy consumption. Up to its launch at K2010, hydraulic machines using accumulators for the injection movement were the standard for the production of caps. However, Engel claims that the E-cap is the most energy-efficient cap machine on the market and at the same time the only high-performance machine tailored to the requirements of the caps and closures industry providing all-electric operation even with a clamping force range as high as 4,200 kN. It has an average return on investment of less than two years, says the company.

"Since 2010, the requirements for beverage caps have changed substantially," says Friedrich Mairhofer, Product Manager for all-electric injection moulding machines. "This is why the continuous further development of E-cap now is being integrated into a next generation machine. Continuous part weight reductions play a central role. For still water, caps with a weight of significantly less than 1g are produced today. As a result, the cooling and cycle times have continued to drop. Where the cycle times ten years ago were still 2.5s, today's cap machines need to be able to

IMAGE: BERICAP



Left: Filling aid for AdBlue tanks in diesel cars from Bericap

Right: Caps are becoming lighter, causing increasingly tough challenges for injection moulding machine technology, says Engel

produce at 2s intervals and faster.”

When developing the new generation of machines, Engel says that the main focus was therefore both on performance and stability. The new E-cap achieves faster mould opening and closing movements and is designed with a more stable machine bed for more frequent load cycles.

The company has demonstrated an E-cap 2440/380 producing 29/25 caps in a 96-cavity mould from Plastisud. The shot weight is 1.3g per cavity with a cycle time of less than 2s. An HDPE from Borealis/Borouge is processed. The system is equipped with camera-supported 100% quality inspection by IMDvista and a dry air system by Eisbär. Further system partners are Piovan, PackSys Global and PSG.

The reinforced frame and mould mounting platens on the new E-cap ensure good stability of the machine movements even with extremely short cycles and small shot volumes. The company says that the result is outstanding reproduction of surface detail and a maximum number of good parts. The fast dry cycle times of 1.3s with the E-cap 380, for example, and the parallel movements included in the standard right from the outset make an important contribution to achieving cycle times of less than 2s.

Ejection occurs parallel to the mould opening. What is new is that the ejectors can be amplified by a switchable hydraulic booster on demand. This ensures that the machine operates with the best possible efficiency both during production and start-up after a production interruption. While the caps are not yet completely cooled and easy to demould during ejection in ongoing production, the ejectors have to apply more force in stop situations to remove caps that have already cooled down in the mould. Since production interruptions are rare, it is more efficient to use servo-hydraulic drive amplification than to generally equip the machine with more powerful ejector drives.



IMAGE:ENGEL

The new E-cap generation is offered with two different ejector drive technologies. The machine works with hydraulic ejectors as standard. Servo-electric drives are available as an option, which require around 10% less energy.

In addition, the plasticising unit has been redesigned, because the properties of the materials to be processed have also changed. Raw material manufacturers have adapted their products to lower cap weights. For

CSD (carbonated soft drink) caps, the melt flow index (MFI) of current HDPE grades is 0.8-1.4g/10 min. Very short cycle times require particularly high plasticising rates. Engel has increased the torque of the plasticising drive accordingly and developed both a new plasticising screw and a new highly wear-resistant sliding ring non-return valve specifically for cap manufacture. Both products are part of the standard scope of supply of the new E-cap machines. With its new design, the barrier screw processes high viscosity HDPE in a particularly gentle way, even given high throughput levels, while ensuring a good melting rate and homogeneity of the melt. This further contributes to the high process stability and repeatability of E-cap machines.

Engel adds that an encapsulated toggle lever and a clean linear guide of the moving platen, result in E-cap machines reliably meeting the requirements of strictly regulated production standards of the food industry. The machine's all-electric drive technology makes a major contribution to good energy efficiency. In addition, braking energy is recuperated, reliably preventing the need for expensive peak power. Due to the high efficiency of the drives used, E-cap machines also only require a minimum of coolant. The E-cap 380, for example, operates at high speed with a specific energy consumption of 0.37 kWh per kg of pellets processed. The new E-cap is available in the sizes 220, 280, 380 and 420 with clamping forces from 2,200-4,200 kN.

KraussMaffei has reduced the dry-cycle times of the high-performance Netstal Elion by up to 0.2s across the entire model range. The shorter dry cycles are available for all models with aXos version 8.2.0 and upwards. The company says that this update for the series incorporates the latest controller technology insights, which had already been applied to the Netstal Elios series. The additional speed is made possible through the adaptive optimisation of the acceleration and deceleration ramps for the clamping unit drive.

Below: With extremely short cycle times of less than 2s, Engel's new E-cap machine ensures high precision and repeatability



IMAGE:ENGEL

IMAGE: KRAUSSMAFFEI



Above: The dry-cycle times of the Netstal Elion have been reduced by up to 0.2s across the entire model range

The result is that the maximum moving speed will be reached faster and can be maintained longer before the moving mould plate is decelerated and the toggle lever mechanism transitions to building up the clamping force – all without compromising mould protection.

The company adds that taking into account the potential mould weight allows shorter production cycles. However, a shorter dry-cycle time does not automatically mean a faster cycle under real production conditions. That is why the new control algorithm takes into account the potential tool weight based on the set installation height and incorporates it in the control of the acceleration and deceleration process. This allows speeding up of production and further productivity increases.

For high-performance closure applications, a Netstal Elion 4200 with a 96-cavity mould was set up to produce type 29/25 HDPE closures. One closure weighs 1.23g. Due to the optimised control, the cycle can be shortened from 2.77s to 2.6s. The hourly output goes up from 124,750 to 132,920 closures, which is a productivity increase of 6.5%.

Borealis has developed BorPure RF777MO for flip-top cap applications. Based on Borstar Nucleation Technology, this new resin fulfils value chain demand for high-quality solutions offering good organoleptics. A next generation random polypropylene (PP), BorPure RF777MO has been designed for use in flip-top caps, a growing caps and closures market segment.

The company says that the caps and closures industry needs to respond to a broad and diverse set of requirements. Converters demand innovative material solutions that reduce energy consumption and help increase productivity on injection moulding lines. Resins must offer easy processability, consistency, high quality and provide optimal performance on the capping line. For brand owners and

final consumers, caps and closures must secure package contents, provide ideal organoleptic properties, safety and convenience. They must also stand out on the retail shelf and, increasingly, offer the lowest possible environmental footprint. This expansion of the BorPure family of multimodal polyolefin resins with good taste and odour properties enables Borealis to support its value chain partners better in fulfilling this diverse range of demands, it says.

The company adds that BorPure RF777MO is based on in-situ nucleation technology, which helps producers enhance productivity and sustainability. Cycle times are reduced. For certain cap applications, cycle time reductions of more than 10% can be achieved due to fast crystallisation behaviour. The impact of colouring on dimensional stability can be lowered due to fast colour change during processing without having to change process parameters. In addition, energy consumption can be reduced resulting from lower barrel temperatures. Finally, the overall CO2 footprint can be lowered due to reduced energy consumption and faster cycle times on injection moulding lines.

For brand owners, BorPure RF777MO offers high transparency in combination with good gloss and hinge performance. Testing by an independent institute in Europe has confirmed the good organoleptic properties and the suitability of RF777MO for the most sensitive beverage and food applications. Hinged caps made using this new resin are particularly robust, demonstrating good hinge strength and stability. As a mono-material solution, caps made using RF777MO are

also 100% recyclable, says Borealis.

Ineos Olefins & Polymers is partnering with **Forever Plast**, a leading polymer recycling technologies operator in Italy, to develop a range of new polyethylene grades that mirror Ineos' virgin grades for injection moulding and compression moulding machines. The new Recycl-IN products take PCR PE from used bottle caps and carefully blend them with highly engineered virgin polymer to create new high-quality caps. Over the next five years,

the companies say that 6.5 billion bottle caps will be diverted from the waste stream to be recycled.

The initiative is an expansion of the Ineos Recycl-IN polymer range into the PE non-food caps market. "For a while PET bottles have been increasingly recycled but this is one of the first circular developments to tackle the caps," says Iain



IMAGE: BOREALIS

Right: Borealis has launched BorPure RF777MO, which is designed for flip-top cap applications

Right: Ineos Olefins & Polymers is partnering with Forever Plast to use PCR from used caps in new closures

Hogan, CEO of Ineos Olefins and Polymers. "This is a major step forward. We are creating a truly circular approach to ensure used bottle caps are recycled and returned to the market as new highly engineered high-quality caps, rather than being thrown away or wasted."

SABIC has opened a Technology and Innovation Centre dedicated to caps and closures in Geleen, Netherlands, located in SABIC's Global Technology Center for Europe on the Chemelot Campus. The opening ceremony of the new facility was led by Sergi Monros, SABIC Vice President of Performance Polymers & Industry Solutions, Petrochemicals. The facility opening comes a year after SABIC established its Caps & Closures industry segment organisation.

"With our dedicated organisation, we already have a strong focus on innovation-driven solutions to meet the changing market trends that our customers within this strategic segment are demanding," says Monros. "This new state-of-the-art facility will enable us to accelerate the pace by using market-leading materials and technologies aimed at a range of related applications – not only caps and closures, but also pumps, dispensing systems and other product delivery mechanisms for beverages, food and non-food applications."

Monros points to the growing need for creative solutions that are sustainable, cost-efficient and compliant. These solutions are coupled with the increased number of regulations governing product safety and consumer well-being. "End-users are looking for convenience too, and we are always thinking about new ways to improve functionality," he says.

Below: SABIC has opened a Technology and Innovation Center dedicated to caps and closures



IMAGE: INEOS

SABIC says that it is developing technologies related to both new material development and to application testing. Polymers developed specifically for applications in this sector help enable, for example, lighter caps, and pumps and dispensing systems that are more efficient and easier to manufacture, all the while supporting customer efforts to improve overall sustainability. The centre includes facilities that allow SABIC to simulate the real-life performance of finished products. The research laboratory has equipment for testing material characteristics such as mechanical properties, dimensional stability and environmental stress cracking resistance. Cap specimens can be produced in-house for performance testing for potential applications and for the development of improved products. There will also be capability for developing and testing new product designs.

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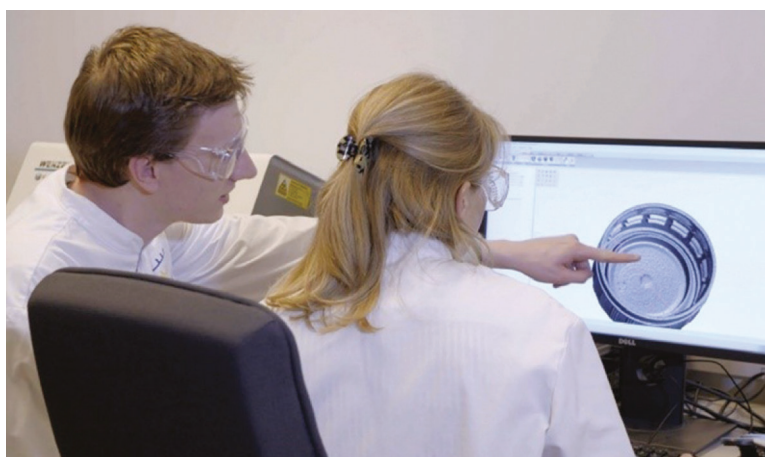


IMAGE: SABIC

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