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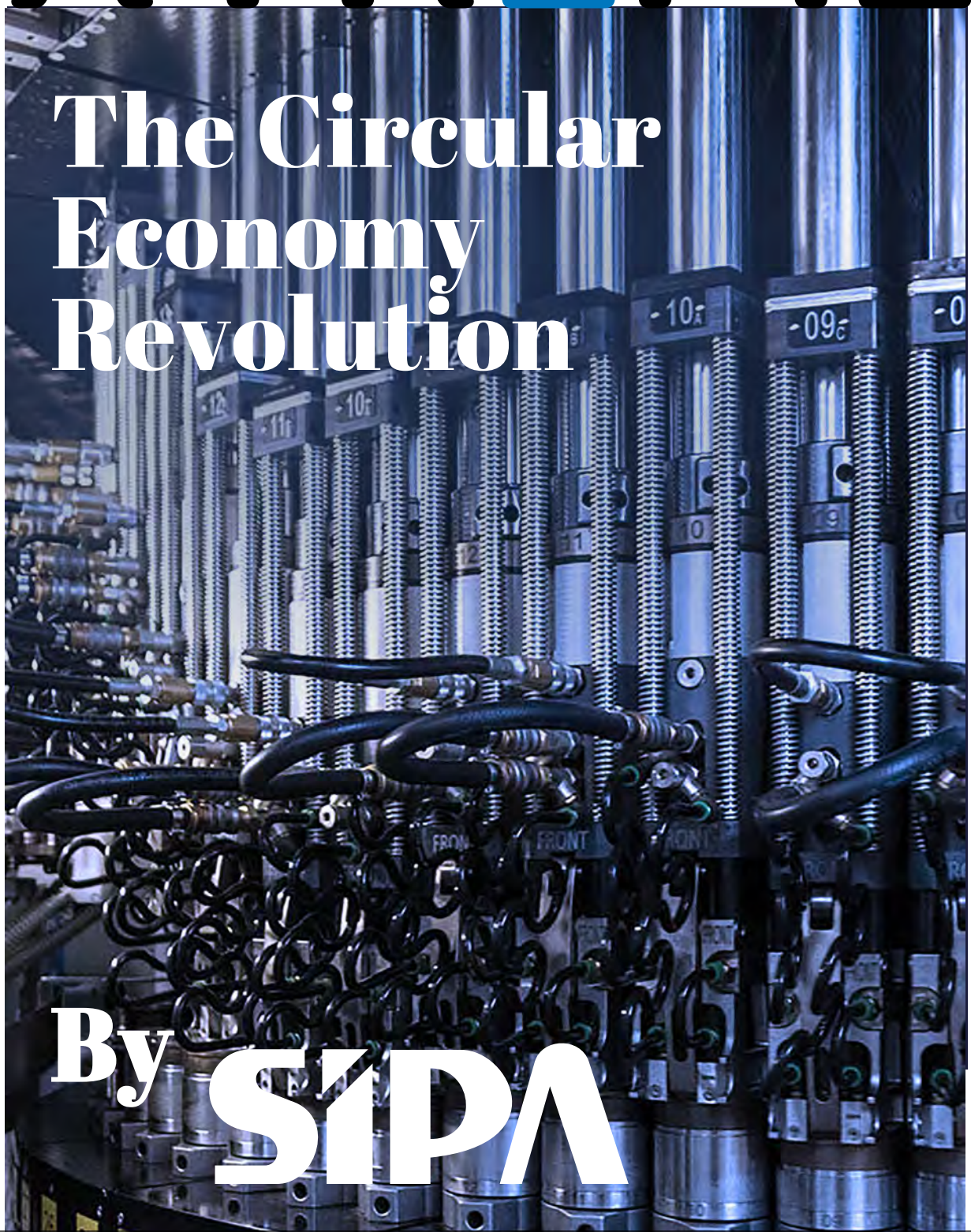
XTREME



The Circular Economy Revolution

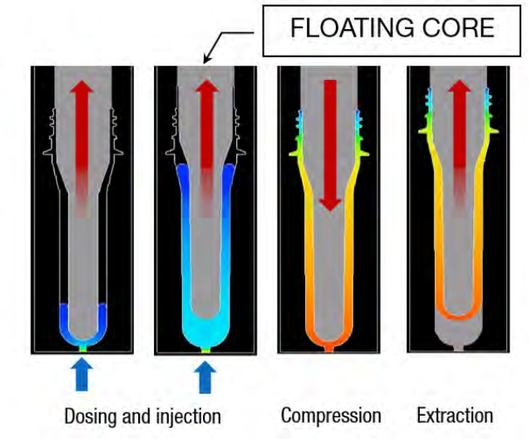
By SIPA

NO MACHINE MAKES PREFORMS IN THE WAY XTREME DOES.

We are at the beginning of a new age in PET preform production: the XTREME age. **SIPA's XTREME** injection-compression molding technology is like no other in its ability to make high performance thin walled PET bottle preforms. **What's more, it does so in a highly energy-efficient way, and just as quickly as traditional injection molding technology**. This remarkable achievement is due to its continuous mode of operation, which allows upstream and downstream connections to optimize several production processes. XTREME technology uses a carousel system in which individual molds are fed by a continuously running extruder. The carousel rotates at high speed, with all mold opening and closing movements, as well as transfers, driven by cams, making it impossible for any mistakes to be made when setting up the machine. **A typical XTREME preform for a 0.5-L bottle is immediately distinguishable from its injection molded counterpart by its perfect injection gate.** What is not so obvious is the difference in wall thickness. The base of the XTREME preform is 33% thinner than its rival: 1.0 mm versus 1.5 mm. Extra length and lower thickness together provide for a more optimal stretch ratio when the preform is made into a bottle. In fact, L/T ratios achievable with XTREME technology are indisputably the highest in the industry. To achieve such lightweight preforms with very thin wall thickness using standard injection molding, a massive amount of pressure would need to be used – something like 1200-1500 bar when measured at the machine nozzle. That puts an almost incredible amount of stress on the polymer. **By contrast, XTREME technology running with the same output requires a melt pressure of only 150-300 bar – less than 20% as much.**

Floating Cores

The main reason why it is possible to fill the molds using XTREME technology using such low pressure is the floating core. With injection molding, when melt is injected, the molds are already closed and the core position is fixed. So if you want a preform with a base thickness of 1.5 mm, all the melt has to pass through a passage 1.5 mm thick before it can fill the cavity. With XTREME technology, when the melt is injected, the core is shifted up due to the melt pressure and the melt passage is therefore far wider, at 10 mm. **Then, during compression, the core moves into its final position, forcing the melt up to the top sealing surface.** The net effect is a much more gentle treatment of the melt. All this means that acetaldehyde (AA) levels are reduced by



UP TO 40% COMPARED WITH TRADITIONAL INJECTION MOLDING

and resin intrinsic viscosity (IV) falls far less: over 70% less in fact. This has a direct and positive effect on the mechanical properties of the bottle. Improved distribution of material around the base of the preform also enables improved cooling, with no crystallization in the gate area. Furthermore, there is no sign of the "crown" gate typical of injection molded preforms.

Outstanding Design

Not only do preforms made with XTREME technology have optimal L/T ratios, they also have optimal designs overall, with a much better distribution of material throughout the part than can be achieved with injection molding. While the base is much thinner, the lower sections of the walls are actually thicker, which has another important influence on the mechanical properties of the finished bottle. **In addition, XTREME preforms have thinner walls just below the support ring**, where in injection molded versions there is an excess of material. As much as 0.6 g can be shaved off the weight of the preform in this area alone.

Levels of acetaldehyde (AA) given off during the process are extremely low, making XTREME the best solution on the market for high-speed production of lightweight preforms destined for the production of bottles for water and aseptic filling.

Lower Costs

There are still more advantages.

> “It is cleaner, because it is oil-free.”

XTREME is unique in being able to produce preforms with different formats at the same time; this advantage is most apparent when **XTREME** is being used to produce preforms only needed in reduced quantities. Uptime is higher, because mold changeover times are far lower – well under two hours, compared with up to five hours in injection molding systems.
Another important plus for XTREME is that clamp tonnages are far lower than in injection molding, since molds are closed three at a time rather than all at once. Required clamp tonnage is just maximum two tonnes per cavity, rather than several hundred. This results in less wear on the molding components.

Total control

XTREME provides total real-time control over preform quality, with a highly sophisticated multiple camera system. Up to six cameras check neck finish, body and gate, and also register black specs, making it possible to achieve the strictest quality criteria in the world. In the unlikely event of a preform not complying to specification, it is automatically ejected. Preform quality control also extends to temperature measurement with an optical pyrometer. Once the preforms have passed the quality test, they move to a bin, which is filled with exactly the number preset on the machine control. **XTREME in combination with integrated components upstream and downstream, contributes to huge energy savings.** In the XTREME Renew configuration for production of preforms from post-consumer recyclate, energy is saved through the elimination of an extrusion phase when running rPET flakes, since no granulation phase is involved. This yields a reduction in energy consumption of as much as 30%. When XTREME is integrated with a bottle blowing system, as much as 25% energy savings are possible, through the elimination of infrared ovens to reheat preforms.

ALL AROUND THE WORLD

SIPA SO FAR HAS SOLD EIGHT XTREME SYSTEMS, TO CUSTOMERS IN SIX DIFFERENT COUNTRIES, AND EACH ONE HAS A DIFFERENT CONFIGURATION.

Three systems operate as stand-alone configuration, one with 72 cavities and two with 96 cavities. Four systems are in the XTREME Renew configuration.

An additional system is integrated downstream in what SIPA calls XTREME Sincro Cube, in “pellet to pallet” systems that go all the way from granules to bottles that are filled, labelled, and packaged.

In Japan, three machines are producing preforms destined for aseptically-filled bottles – two of them using rPET. In South Korea, a system will produce preforms for mineral water bottles. In the United Arab Emirates, production will be destined for juice bottles. In Poland, a third system making use of PCR will soon be in operation, making preforms for bottles for water and carbonated soft drinks. In Brazil, detergent are bottled in XTREME preforms, as they will in a system in Mexico.

FLEXIBILITY

A key, unique, feature of XTREME is that it can produce preforms in two different formats at the same time. The preforms can be of different weights, for bottles with different volumes, and they can also have different neck sizes.
Flexibility of the system is also demonstrated in its ability to be connected directed to a SIPA XTRA rotary stretch-blow molding unit, in a system comparable with a single-stage injection-stretch-blow molding (ISBM) machine – except that it is much more productive. Integration can then be taken even further, by connecting rotary stretch-blow molding to a filling unit.

Flexibility comes in the form of XTREME's rapid mold change system too:

THIS ENABLES THE OPERATOR TO COMPLETELY CHANGE ALL THE MOLDS ON THE CAROUSEL IN UNDER TWO HOURS

well under half the time it takes to change a mold on an injection molding machine – further adding to uptime and overall productivity.

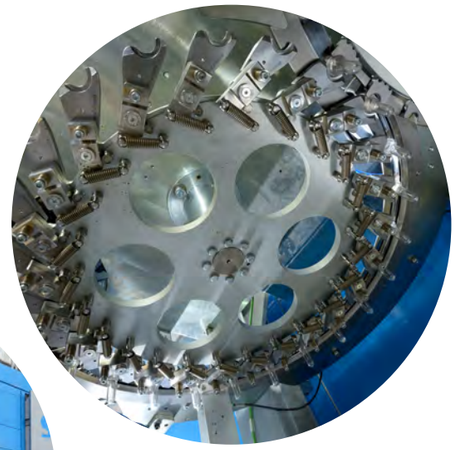
Alternating Mold Sets

The first XTREME to go into commercial operation simultaneously producing two different preforms – a 72-cavity stand-alone version – will soon start up at a food and beverage company in the United Arab Emirates. The two sizes of preform weigh 16g and 21g respectively; both have a 38-mm neck finish. All preforms will be converted into bottles for fruit juices. Output is 20,000 preforms/hour.
At first glance, this ability to make two different preforms at the same time may sound like something of a gimmick. But it is nothing of the sort. Consider the case of a converter introducing a new preform size (let's call it preform B) onto the market. The likelihood is that low initial volumes will not justify the investment in a full set of stacks. In that case, it is possible to equip only half of the molding wheel with molds for this new preform size while the other half can work with a different, existing, format (preform A). **Later, when sales volumes increase, the machine can be equipped with a full set of molds for preform B.**

Just like all other XTREME models, versions simultaneously producing preforms with different sizes are equipped with an extruder providing continuous melt flow. The two kinds of molds are installed alternatively, in groups of three on the molding wheel (again, just like on 'regular" XTREME units), and the transfer wheel is equipped with personalized grippers for each of the two preforms, based on the body shape.
Alternation of mold sets of different sizes provides an equilibrium in the overall system, allowing the extruder to run at a constant rate and so providing unchanging melt quality.
Due to the individual melt dosing and injection units ("shooting pots") for each and every cavity, the software of the machine is able to detect the preform size in each position and discharge them in the correct bin at the end of the process.
The cycle time of the machine is determined by the preform with the largest wall thickness. If the process requires it, an injection delay can be set for the lighter preforms.
Inspection cameras installed both on the transfer wheel and on the PMC (post-molding cooling) system check the neck and body of the two different preforms, using special software. The preforms can be discharged on two separate T-belts (each with two boxes). The discharge position is selectable from the HMI.

Integration Downstream And Upstream

XTREME can be seamlessly integrated with other key pieces of equipment in the total PET bottle making and filling process, upstream (for processing post-consumer recyclate, for example – see accompanying article) and downstream. It can be connected with a stretch-blow molding unit, in a system called XTREME Sincro, **which in turn can be connected to a Flextronic filling station to form XTREME Sincro Cube.**



DOWNSTREAM INTEGRATION: XTREME SINCRO, FROM PREFORMS TO BOTTLES

XTREME is a rotary system, so it fits perfectly with SBM systems. Integrating preform production directly with bottle blowing has massive advantages in many ways. Bottle quality is better because overall process stability is likely to be higher than when running two separate systems. Also, because the preforms pass directly from the compression-injection unit to the blower, they don't get scratched in any storage bins. **Elimination of preform cooling and reheating ovens cuts total energy consumption by around 25%.**

And because there is no need for preform storage and a long IR heating oven, total space requirement can be cut virtually in half. XTREME Sincro, with its single-step bottle production process, provides the flexibility of a conventional two-stage system involving separate preform injection and blowing units, with the energy advantages of single-stage bottle production. But compared with its ISBM equivalent, **XTREME Sincro has the advantage of much easier and faster mold changing, and also higher productivity. While the fastest single-stage ISBM system can produce around 30,000 bottles per hour, an XTREME Sincro can reach an output of 50,000.**

DOWNSTREAM INTEGRATION: XTREME SINCRO CUBE, FROM PREFORMS TO FILLED BOTTLES

Filling units too are rotary in design. It seems natural, then, to integrate filling process in the system. All three systems can also be pneumatically actuated, providing high levels of cleanliness catering for many product types: blowmolder XTRA can produce hot- and cold-fill containers, without any changes to the system coupling with almost all SIPA filling monoblocs. A SIPA customer in Brazil was the first company in the world to take full advantage of this interconnectability. It went into production a year ago with an XTREME Sincro Cube. This has 72 cavities on the molding wheel, 16 blowing cavities, 60 filling valves, and 15 capper heads. The fully integrated system can produce over 33,000 filled and capped bottles per hour, using material that contains 70% post-consumer recyclate.

FULL POTENTIAL, UPSTREAM AND DOWNSTREAM INTEGRATION: XTREME RENEW SINCRO CUBE. FROM 100% RPET HOT WASHED FLAKES TO FILLED BOTTLES

XTREME Renew integrates a SIPA XTREME system upstream with an Erema Vacurema recycled PET flakes decontamination system suitable for bottle-to-bottle applications. The Erema machine is fed with 100% hot washed flakes and directly feeds the SIPA machine with melt that is converted into food grade preforms in a single process. And here comes the exceptional chance to produce preforms, blow and finally fill 100% rPET containers produced from hot washed flakes. This is a unique opportunity for players to be totally compliant with the rules of Circular Economy, saving energy, emissions and space!

For Many Product Types

XTRA has the both the speed and the versatility to match XTREME. It can produce bottles from 0.2 up to 3.5 liters in volume, quickly and easily. It can also accommodate different neck sizes (28/38 mm). This flexibility is complemented by the ability of the machine to produce hot- and cold-fill containers, without any changes to the system.
XTRA was designed from the ground up to be able to integrate and interact with machines upstream and downstream, creating high-performance production systems consisting of different products that all speak the Not only does it connect directly with XTREME, but it also fits perfectly with the filler.

SUSTAINABILITY

There is considerable discussion in the world at large about the problem of plastics waste and how little plastics packaging is recycled after use. Companies all along the PET bottle production and filling chain need to engage in this discussion. SIPA considers itself a leader in this engagement. **The European Union is cracking down on plastics waste, as it pushes forward its plans for the Circular Economy.** It is limiting the use of single-use plastics and setting tough targets for use of recycled materials. **Under the Single-Use Plastics Directive, PET bottles will have to contain at least 25% recyclate by 2025, rising to 30% by 2030.** It is estimated that to meet the 2030 target, the EU will require double its current rPET reprocessing capacity. Today, less than 60% of bottle PET is collected for recycling and only 6% makes it back into new bottles. There is a clear and strong need for new and improved PET recovery and recycling technologies to make these targets achievable. Fortunately, moves are being made to meet that need.

SIPA HAS TAKEN A LEADING POSITION IN THE PET PACKAGING SECTOR IN ITS NUMEROUS INITIATIVES TO INCREASE THE SUSTAINABILITY OF PET.

Over the years, SIPA has put considerable effort into developing ways to reduce the amount of PET used in individual containers for example, and to develop processing technologies that are more energy efficient. Its latest and possibly most radical development is XTREME Renew. This is a patented technology, developed in collaboration with Austrian recycling technology specialist Erema, which brings new levels of sophistication – and sustainability – to converting used PET bottles back into new ones.

> “XTREME Renew technology is unique in the world in its ability to produce top-quality preforms bottles, suitable for food contact, directly from flakes of post-consumer waste, in a single heat cycle.”

> XTREME Renew integrates a SIPA XTREME system upstream with an Erema Vacurema recycled PET flakes decontamination system suitable for bottle-to-bottle applications.

The Erema machine is fed with 100% hot washed flakes and directly feeds the SIPA machine with melt that is converted into food grade preforms. Material feeding flexibility means that a mixture of flakes and virgin PET is also feasible (by pre-mixing the two resins, in any percentage), while the addition of various types of additives is also an option prior to the extrusion phase.

Drying, crystallization, homogenization and decontamination of the flakes takes place in tanks positioned ahead of the Erema extruder.

A solid state polycondensation (SSP) process assures an IV increase of up to 6% or 10%, depending on the configuration.

The flakes are transferred under vacuum to the extruder, with the melt being filtered to remove any foreign solid contamination up to a fineness of 32 micron. Vacurema technology uses less energy than alternative systems, improves the color of the processed material, and keeps levels of acetaldehyde very low.

The Vacurema system also creates a highly homogenous melt, even if input material has variable viscosity.

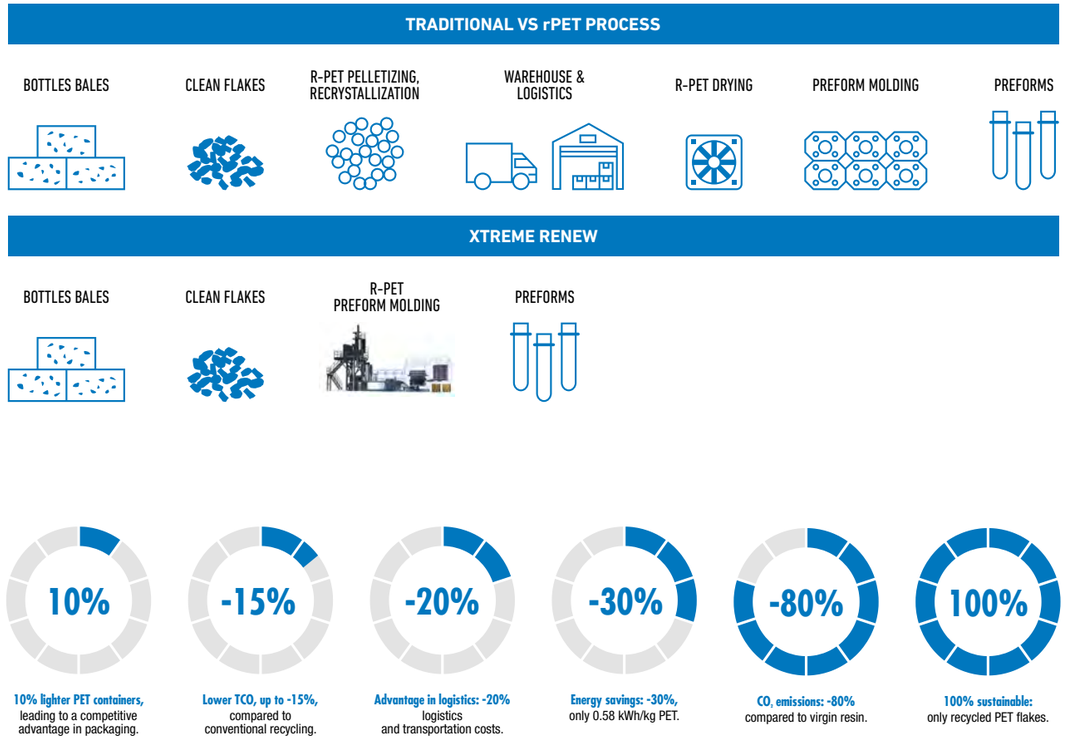
The melt is then fed straight to the XTREME molding wheel.

Savings in Energy and CO_2

In conventional PET recycling systems, the extruder processing the bottle flake converts it into granules for processing at a later stage. This involves cooling the melt into a solid, cutting it up, drying it, and then later remelting it – processes that all require energy. By eliminating the standard pelletizing process of the rPET stream, the logistics and warehousing related to the pellets distribution, its subsequent drying and extrusion in a traditional injection molding machine, it is possible to cut electricity consumption by 30% and CO_2 emissions by 80% compared with a system making preforms from virgin PET.

The quality of the molded preforms is superior to those produced from rPET using conventional two-stage routes, thanks to the single thermal history of this highly innovative recycling process.

That means lower PET degradation, resulting in better bottle aesthetics that are easy to see with the naked eye in terms of improved color. TCO can be cut by as much as 15%. The price of flakes is lower than virgin material and much lower than rPET pellets. Requirements for warehousing and transport are lower, with total space needed reduced by up to 20%.

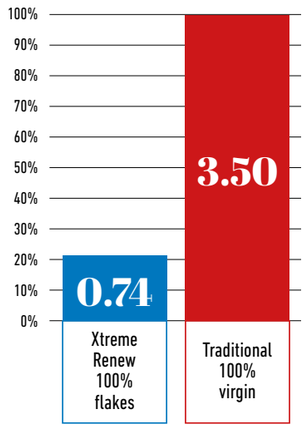


COMPARISON 1

- Xtreme Renew, 100% rPET flakes
- Traditional preform injection system, 100% PET virgin PET granules

-79%

Xtreme Renew, 100% flakes
Traditional injection 100% virgin

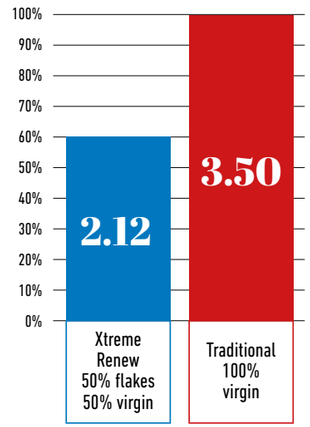


COMPARISON 2

- Xtreme Renew, 50% rPET flakes + 50% PET virgin granules
- Traditional preform injection system, 100% PET virgin granules

-40%

Xtreme Renew, 50% flakes
Traditional injection 100% virgin

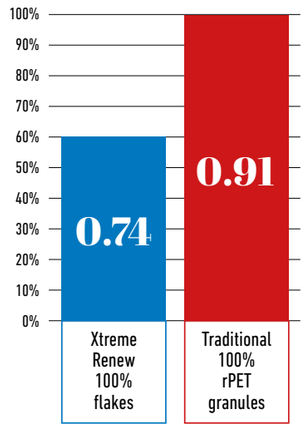


COMPARISON 3

- Xtreme Renew, 50% rPET flakes + 50% PET virgin granules
- Traditional preform injection system, 100% PET virgin granules

-18%

Xtreme Renew, 100% flakes
Traditional injection 100% rPET granules



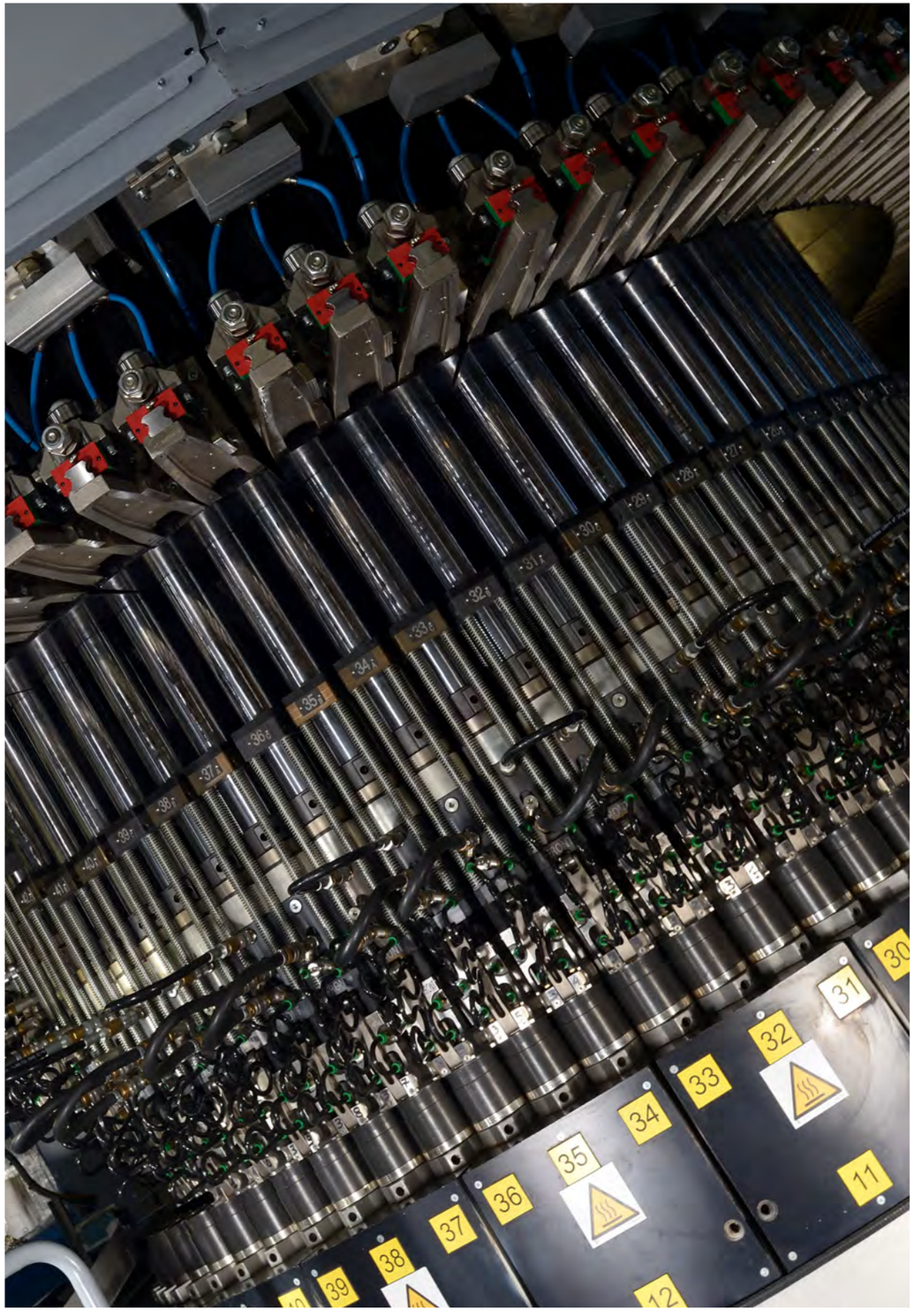
Global warming (GWP100a) [kgCO2eq]

LCA Confirms The Savings

SIPA has carried out a life cycle assessment on its XTREME Renew process, so it can quantitatively compare its potential environmental impact in production of preforms from 100% recyclate (rPET) with a traditional process for producing PET preforms from virgin material (using a SIPA XFORM injection molding system). The results were independently verified.

The LCA considered the contribution of the production of the raw material, transport of the raw material, production of the bottles, and construction of the plant. It showed that the global warming potential of XTREME Renew is 79% less – 0.74 kg of CO_2 equivalent for every kg of preforms produced, compared with 3.50 kg.

Comparing the XTREME Renew process with a traditional process for producing PET bottles from rPET, which uses granules produced from flake, the difference was still important, at 18%. Adoption of XTREME Renew is beginning to take off around the world. The first adopter was major recycling company Kyoei in Japan, in partnership with Suntory, a world brand in packaging. They went into industrial production with a 96-cavity system in July 2018, and brought a second line into operation this February. A third line is being shipped this quarter to a customer in Poland, and a fourth will be shipped to a Mexican customer during the second quarter of next year. All these lines can produce tens of thousands of preforms every hour using 100% hot washed flakes.



LIGHTWEIGHT

XTREME technology has the inherent advantage of producing preforms with lower and more uniform wall thickness distribution around the base. With injection-compression it is possible to produce preforms that are close to 10% lighter than even the lightest preform produced by conventional injection molding—but without losing any key properties. More weight can be shaved off the body and base of the preform than ever before.

Whereas until recently, the maximum length-to-wall thickness ratio (L/t) of a preform was little more than 45, SIPA's XTREME technology makes an L/t ratio of 65 a commercial reality. This potential for lightweighting with XTREME is, well, extreme.
Given the long history of weight reduction in injection molded PET preforms over the years, the fact that it is now possible, in a single swoop, to slash off so much more weight is remarkable.

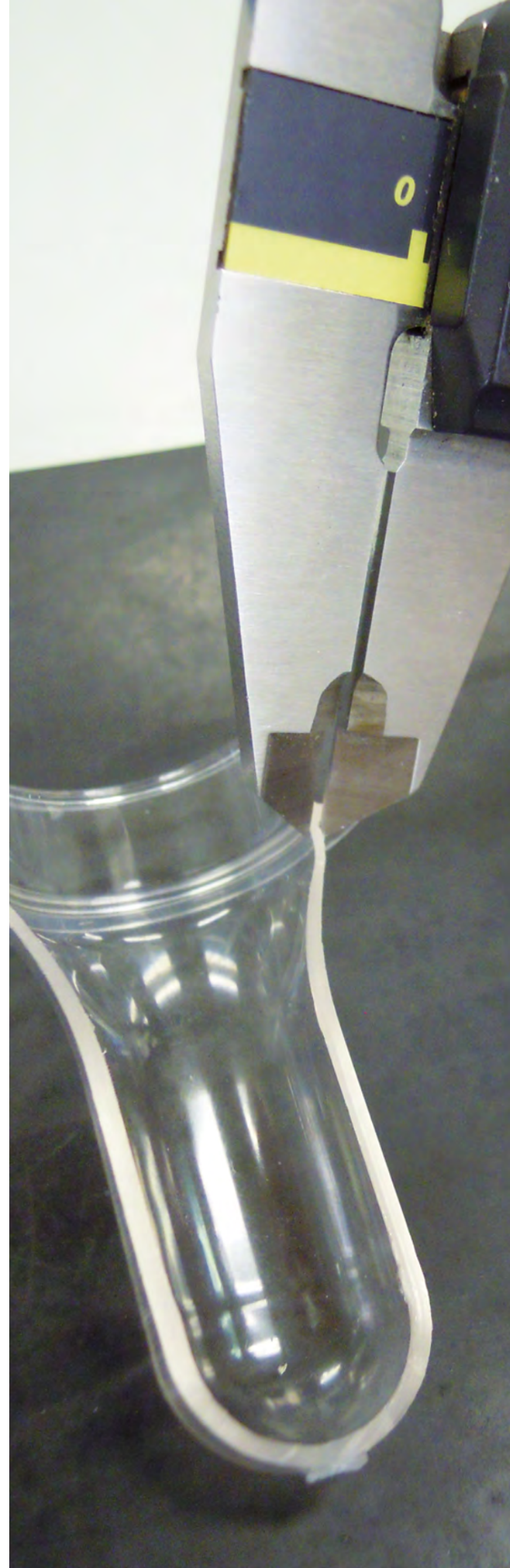
SIPA CAN DESIGN PREFORMS SPECIFICALLY FOR XTREME, TAKING INTO ACCOUNT THE FACT THAT THEY ONLY HAVE TO GO THROUGH A SINGLE THERMAL CYCLE ON THE WAY TO BECOMING A BOTTLE, AND SO DO NOT HAVE TO RESIST SO MUCH MANIPULATION AS IN TWO-STAGE SYSTEMS.

Crucially, the mechanical performance of the bottle still meets customer requirements, since the design of the preform is governed more by end-user requirement than it is by the requirements of the production process.

New Design Possibilities

XTREME can make preforms with very thin walls, with a more even wall thickness distribution, and which are wider and/or longer than standard injection molded preforms. The thickness in the base of an injection-compression molded preform can be as low as 0.95mm, compared with 1.6mm on a normal preform. **All this adds up to extra freedom in designing preforms** according to the intended purpose of the final container, rather than to accommodate restrictions in the production processes.
Consider: XTREME can produce preforms for 220-mL bottles that weigh just 3.9g. No other process comes close. Today, an injection molded preform for a similarly sized bottle weighs at least 4.5g.

> "XTREME can produce preforms for 220-mL bottles that weigh just 3.9g."



Weight Control Leads To Increased Performance

Even though XTREME preforms are much lighter than injection molded preforms, their mechanical performance is outstanding.

How is this possible?
Because the material in the preform is inherently stronger, since it has a higher IV; and because the weight is all in the right places. There is less material around the gate and under the support ring, where in injection molded preforms there is too much; and there is more material on the bottom, away from the injection point, where normally there may be too little.
As for the gate area itself, there is no crystallinity, or crown gate.

An example to demonstrate the advantage of the system is in production of small bottles for drinking yoghurt and probiotics.
When these bottles are produced on two-stage injection molding and stretch blow molding systems, they have to undergo quite a lot of manipulation.

It's the same amount as in other two-stage systems making bigger bottles, but the problem here is that these little bottles have virtually no neck, so they are difficult to hold without leaving a mark on the body of the bottle.

In a single-stage system, the body never gets touched.
SIPA is in the process of delivering a stand-alone 96-cavity XTREME system to a customer in Korea.

The customer was particularly impressed by the ability of the system to take weight out of preforms, and also in the 100% in-line inspection.

SIPA's preform design experts took on the task of designing the preforms that will be produced on the new line, due to go into production before the end of the year.
They lightweighted the customer's existing preforms by no less than 11% taking total weight down to 16g, and improved the stretch ratio.

> "THE PREFORMS, WITH 30/25 NECK FINISHES, WILL BE BLOWN INTO BOTTLES FOR MINERAL WATER. THE UNIT WILL MAKE 40,700 PREFORMS PER HOUR."

PET PLANET

SIPA had the pleasure in late September of welcoming Alexander Büchler, the publisher of PETplanet, to its headquarters in Vittorio Veneto, Italy. Alexander came to talk with Gianfranco Zoppas, President of SIPA and to get a close look at SIPA's operations. He also spoke with all the company's Business Unit directors (see PETplanet October to read the interviews).
While he was with us, Alexander had the opportunity to see several XTREME injection-compression molding systems being put through their paces before they were shipped off to eager customers.

There were four in all: a stand-alone 96-cavity system for a Korean customer producing bottled water; a 72-cavity system that will be making preforms in two different sizes at the same time for fruit juice bottles at a customer in the United Arab Emirates; and two XTREME Renew systems, one with 72 cavities for a company bottling water and carbonated soft drinks in Poland, and the other a 96-cavity system for a company making detergent bottles.
Alexander put it to Mr. Zoppas that highly integrated systems favored by SIPA tend to have less-than-optimal efficiencies, because the inefficiencies of the many individual components all add up.
The SIPA President said he had heard the same argument many years ago, when the company began integrating stretch-blow systems downstream, but these systems are now the norm.

> The integrated system from preforms to filled bottles runs in such a stable way that the overall efficiency of the entire line is above 90%, and the advantages of the significantly lesser logistics and enormous energy savings from working with a single thermal cycle are overwhelming

said Mr. Zoppas.
All in all, we think Alexander Büchler had a full day! We thank him for his time.

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