Working With Recycle

It Takes a Little Getting Used to

What should you know about processing post-consumer plastic? Are there any technical hurdles? Molders and extruders that successfully use a lot of PCR say it's easy—once you learn how.

Molders and extruders who successfully use post-consumer recycled (PCR) plastics say it took them six to 18 months to learn how. And the learning process is continual, because no sooner do they master processing one recycled material than the source or composition of the feed stream shifts. They find their PCR contains a new coextruded layer, label or additive so they have to readjust their processes accordingly.

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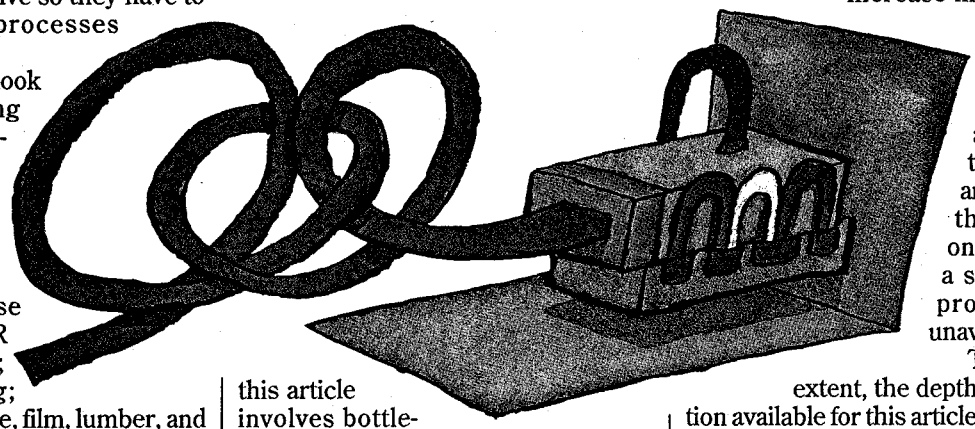
Here is a close look at how that learning process has progressed to date, based on plant visits and interviews with 50 processors of PCR. The emphasis here is on those who are using PCR for blow molding; injection molding; and extrusion of pipe, film, lumber, and sheet. Although PET has the highest recycling rate of any material, most of it goes into fiber, which is not considered in this article. Recycled PET is also extruded into sheet and engineered compounds. Most of the plastic-to-plastic recycling that is within the scope of this article involves bottle-grade HDPE, whose fractional melt-flow rate and density limit its reuse possibilities. This material blow molds and extrudes easily, but is tough to injection mold—some who've tried compare it to "molding chewing gum"—and virtually impossible to rotomold.



Several processors are blending recycled LLDPE from stretch wrap into film and injection molded parts for added toughness. However, recycling of LLDPE and HDPE film from grocery bags, PVC bottles, and PS packaging is still relatively small, and markets for the reclaimed material are smaller still. For example, despite a reported tenfold increase in PVC post-consumer recycling poundage last year, any efforts to identify anyone using the material on more than a small scale proved to be unavailing.

To some extent, the depth of information available for this article was limited by the extraordinary secretiveness of the processors using recycle. Very few of them would permit an editor to see their PCR processing operations—perhaps an indication that they feel they have proprietary technology in this area to protect.

EXTRUSION IS FORGIVING

Plastic lumber was one of the earliest extruded uses for commingled post-consumer plastics. The challenge is to make boards with consistent physical properties. A few months ago, a retailer rejected a whole shipment of over 100 boards from a large manufacturer in Alabama because "some boards were so soft you could wave them like a flag, while others were very rigid," the retailer says. Apparently, the only solution to the problem is to process PCR material in batches that have been carefully blended to a consistent recipe of ingredients (e.g., PCR and/or industrial scrap of different resin types).

Most lumber is made wholly or partly of milk-jug homopolymer. Some is foamed and colored, some not. Eaglebrook Products in Chicago extrudes foam boards for lightweight outdoor furniture. ARW Polywood in Lima, Ohio, extrudes solid boards because it wants them to feel heavy like red or white oak. Three-year-old ARW licenses a proprietary extrusion process from Belgium and says it uses some 15 million lb/yr of HDPE, PET and PP in a precise recipe.

HDPE pipe extruders (mostly corrugated and smooth-walled) use more PCR than any other plastics processors. Use of PCR in pipe is encouraged by several state and federal authorities as a way to support solid waste and recycling objectives. But using post-consumer material isn't recognized by ASTM pipe standards. So pipe makers don't like to discuss their processes or PCR use, except to say that pipe made of 50-100% PCR can match objective ASTM tests. Some pipe makers say it has to be thicker to do so, others say it doesn't with proper process technology. The biggest problem for pipe makers is PP from caps and syrup bottles, of which a relatively small amount can cause weak spots and blowouts, so they test for PP carefully.

Post-consumer HDPE and PET are also extruded into sheets. Coon Manufacturing Inc. in Spickard, Mo., makes HDPE sheet for partitions. Coon had to rebuild the extruder feed section to take flake and added venting to remove moisture, but otherwise the material processes like any other, says president William Coon.

Recycled PET is extruded into rollstock for thermoformed packaging. Ultra Pac Inc. in Rogers, Minn., has processed PET flake for six years. It makes 100% PCR rollstock on equipment from Welex Inc., Blue Bell, Pa., and then thermoforms it. Like Coon Manufacturing, Ultra Pac extrudes flake rather than pellets because it is cheaper. Processing flake also makes it easier to spot contamination and is more consistent in

ILLUSTRATIONS: RICHARD A. GOLDBERG

WHO'S USING PCR: SOME PROMINENT EXAMPLES

Company	Location	PCR	MM lb/yr	Process	Product
ARW Polywood	Lima, OH	Mixed	15 Purchased	Extrusion	Lumber
American Natl. Can	Chicago, IL	HDPE	2 Purchased	Extrusion	Film
Carlisle Plastics	Boston, MA	HDPE, LLDPE	20 Captive	Extrusion	Bags
Clorox Co.	Oakland, CA	HDPE	4 Purchased	Blow Mold.	Bottles
Continental Plastic Container	Norwalk, CT	HDPE, PET	20 Purchased	Blow Mold.	Bottles
Coon Mfg.	Spickard, MO	HDPE	3 Captive	Rotomold., Extrusion	Sheet, Bins
DuraTech Industries	Lake Odessa, MI	HDPE	5 Captive	Flow Mold, Extrusion	Bench Ends
Eaglebrook Products	Chicago, IL	HDPE	7 Captive	Extrusion	Furniture, Lumber
Envirowood	Mt. Prospect, IL	Mixed	7 Captive	Extrusion	Lumber
Genesis Plastics	Charleroi, PA	HDPE, PET	7 Captive	Extrusion	Sheet
Graham Pkg.	York, PA	HDPE	40 Captive	Blow Mold.	Bottles
Hancor Inc.	Findlay, OH	HDPE	50 Purchased[1]	Extrusion	Pipe
Havilland Drain Tile	Havilland, OH	HDPE	11 Captive	Extrusion	Pipe
I.E.M. Plastics	Reidsville, NC	HDPE	12 Captive	Blow Mold.	Flower Pots
Johnson Controls	Manchester, MI	HDPE, PET	24 Captive	Blow Mold.	Bottles
Mobil Chemical	Jacksonville, IL	LDPE, LLDPE	12 Captive	Extrusion	Film, Bags
Owens-Brockway	Toledo, OH	HDPE	30 Purchased	Blow Mold.	Bottles
Petoskey Plastics	Petoskey, MI	LLDPE	5 Captive	Extrusion	Trash Bags
Plasco Group	Azusa, CA	HDPE	3.5 Captive	Extrusion	Bags
Plastipak	Dundee, MI	HDPE, PET	25 Captive	Blow Molding	Bottles
Poly-Anna Plastic Products	Milwaukee, WI	HDPE	5.5 Purchased	Injection Molding	Bins, Pails
Reuter Mfg.	Hopkins, MN	Mixed	1 Captive	Inj. Mold.	Bins
Rubbermaid Commercial Prods.	Winchester, VA	LDPE, LLDPE	4 Purchased	Injection Molding	Waste Bins
Stuart Walker	La Palma, CA	HDPE	1.5 Purchased	Blow Mold.	Bottles
Tucker Housewares, Div. of Mobil	Leominster, MA	HDPE	4.5 Purchased	Blow Molding	Waste Bins
United Resource Recycling	Jonesboro, AR	Mixed	6 Tolling	Cast Molding	Paving Stone
Ultra Pac	Rogers, MN	PET	10 Captive	Extrusion	Sheet
Webster Industries	Peabody, MA	LDPE	35 Captive	Extrusion	Bags
Zarn Inc.	Reidsville, NC	HDPE	12 Captive	Blow Mold.	Bins, Pots

[1] Not Confirmed.

I.V. Maintaining optimum I.V. is a key concern in any use of PET reclaim. The heat of pelletizing lowers I.V.; even the temperature and duration of drying flake affects it. Says Ultra Pac recycling coordinator Robert Parish, "Cycle times are the same as using virgin PET, but the sheet doesn't perform quite as well because of recycled PET's lower viscosity of approximately 0.65."

Creative Forming in Ripon, Wis. (recently acquired by Wellman Inc.), also extrudes PET sheet from flake and sends low-I.V. material out for solid stating to raise the I.V. Lower-I.V. PET processes at lower temperatures: 540 F for 0.9 I.V.; 500-510 F for 0.8 I.V.; and 470-480 F for 0.65 I.V. If the temperature is too high, resin becomes thin like water. "It's much harder to control. The material walks back and forth on the rolls, and you get crow's feet designs," says v.p. of operations Alan Goldman at Genesis Plastics, Charleroi, Pa.

Lower I.V. also means lower melt strength. For extruders, that means the die and roll have to be closer together than with virgin resin—"as close as physically possible," says Ultra Pac's Parish. Roll temperatures have to be maintained more tightly, or recycled PET sheet will stick. "Roll temperature is worth a couple of hours' discussion," Parish warns. "We learned by trial and error. Now when we see problems, we know which way to go."

Custom and beverage-bottle grades of PET are compatible, even though some custom bottles may use a copolymer. The big problem processors have with using custom bottles is foil labels on liquor bottles. Aluminum foil has a similar specific gravity to PET, so these labels introduce a major contamination problem. Ultra Pac had to buy an aluminum detector (from Carpco Inc., Jacksonville, Fla.) to be able to use custom bottles. Even so, Ultra Pac pays a 5¢/lb premium to keep liquor bottles out of its bales.

FILM IS TOUGH

Processors of cast and blown film using PCR face a variety of challenges, depending on the source of their recycle. LLDPE stretch film, collected at break-bulk shipping centers, has good properties and no pigment. A problem

is small amounts of PVC for food wrapping, which is hard to spot and a major production hazard. Mobil Chemical Co.'s Films Div., Pittsford, N.Y., recycles about 6 million lb/yr of stretch into new films of other types. Another problem is the presence of tackifiers, which cause the two layers of the hot collapsed bubble to stick together. Solutions are to add slip and antiblock or use internal bubble cooling.

Mobil also uses some 6 million lb of mixed grocery sacks, comprising about 60% LLDPE and 40% HDPE. These are compatible, but blending must be consistent. So Mobil pelletizes it and blends huge lots of 120,000 lb, which requires special equipment. Still, Mobil says it can reuse the grocery-sack material at no more than a 5% loading or else the film becomes "splitty."

Many bag and film makers that use PCR are vertically integrated with their own recycling. Webster Industries in Peabody, Mass., the country's largest film-to-film processor, collects six different films, including overwrap from meat packing and stretch wrap. Typically, a 200-mesh screen pack is required to trap impurities that could break a bubble.

Other vertically integrated film makers, like the Plasco Group in Azusa, Calif., blend 25% HDPE milk-jug resin into HMW-HDPE to make grocery sacks. The problem is that milk-jug homopolymer and HMW-HDPE used for the bags have different MFR and density (0.96 density and 0.7 MFR for milk-jug and 0.95 density and 0.05 MFR for one HMW-HDPE used). "You have to adjust the chemistry to get miscibility of the two materials. If you don't, the film properties aren't there," says Barry Curtis, partner in EnviroProducts, Auburn, Mass. (affiliated with recycler EnviroPlastics in the same town), which has also developed a blended homopolymer/HMW film.

BOTTLE-TO-BOTTLE BLOW MOLDING

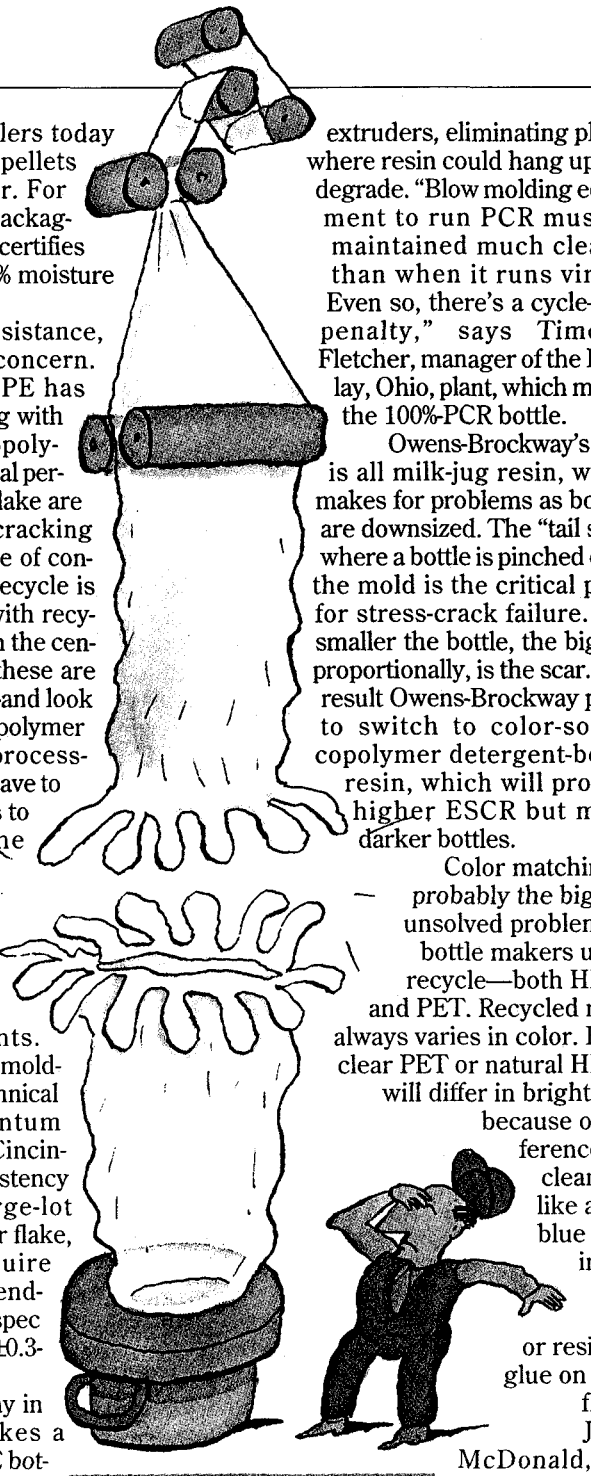
Three years ago, contamination was still a problem for bottle makers. Recyclers made big puffy pellets that were full of moisture, which blew holes in bottles. Dirt, particularly fiber from labels, caused "fish eyes." Now molders say contamination problems are past history. Recyclers today produce small, flat pellets that don't trap water. For example, Graham Packaging Co. in York, Pa., certifies not more than 0.005% moisture in its recycle pellets.

Stress-crack resistance, however, is still a concern. Homopolymer HDPE has poor ESCR. Blending with detergent-bottle copolymer helps, but residual perfumes in detergent flake are themselves stress-cracking agents. A new source of confusion for users of recycle is three-layer bottles with recycled homopolymer in the center layer. Now that these are being recycled too—and look just like all-virgin-copolymer bottles—molders processing copolymer PCR have to adjust their formulas to accommodate the added homopolymer content.

When the MI of blow moldable PCR varies, it produces bottles with inconsistent weights. "That will drive blow molders crazy," says a technical specialist at Quantum Chemical Corp. in Cincinnati. Melt-flow consistency is corrected by large-lot blending of pellets or flake, which may require installing bigger blending silos. Graham's spec on copolymer MI is ±0.3-0.7 g/10 min.

Owens-Brockway in Toledo, Ohio, makes a 100%-recycled HDPE bottle for Procter & Gamble's Downy fabric softener. Owens-Brockway spent years gradually increasing PCR levels in the bottles until it reached 100%. The company designed a new feed system and new die heads for its wheel blow molders and re-engineered the extruders, eliminating places where resin could hang up and degrade. "Blow molding equipment to run PCR must be maintained much cleaner than when it runs virgin. Even so, there's a cycle-time penalty," says Timothy Fletcher, manager of the Findlay, Ohio, plant, which makes the 100%-PCR bottle.

Owens-Brockway's PCR is all milk-jug resin, which makes for problems as bottles are downsized. The "tail scar" where a bottle is pinched off in the mold is the critical point for stress-crack failure. The smaller the bottle, the bigger, proportionally, is the scar. As a result Owens-Brockway plans to switch to color-sorted copolymer detergent-bottle resin, which will provide higher ESCR but mean darker bottles.



Color matching is probably the biggest unsolved problem for bottle makers using recycle—both HDPE and PET. Recycled resin always varies in color. Even clear PET or natural HDPE will differ in brightness because of differences in cleaning, like a few blue caps in the milk jugs or residual glue on PET flake. John McDonald, director of environmental affairs for Continental Plastic Containers in Norwalk, Conn., classifies incoming milk-jug pellets (from six suppliers) on a scale of one to four. One is the

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best and brightest; four is unacceptable. "We tested hundreds and hundreds of samples on a national scale before designating a consistent measuring system. A year and a half ago, most of our suppliers were a two or three. Now all are in the twos, and one company has given us PCR in the ones," he says. When recycled PET yellows or HDPE turns gray, processors add clarifying agents or a drop of blue or red clear tint, respectively.

Bottle molders that use color-sorted copolymers have a far more challenging color-matching problem than users of natural resin. Different amounts of color concentrate must be added to achieve reasonably uniform finished product. Graham color-sorts its own, producing light-blue, light-yellow and salmon pellets in-house. Continental uses color-sorted copolymer (sources include Eaglebrook and Union Carbide) and notes that it even differs regionally. In the Northeast "ROY" (red/orange/yellow) blend tends to be redder than in the South. "Believe it or not, a region becomes consistent, but no two regions are the same," says Continental general manager of purchasing Charles Penrod.

Color streaking is also a problem, especially on larger blow molded parts, because color concentrates don't mix as readily with PCR as with virgin resin, says Rod Repka, manufacturing manager at Tucker Housewares in Leominster, Mass., a div. of Mobil Chemical Co. Tucker blow molds large waste containers and says both LDPE- and LLDPE-based concentrates have caused streaking problems.

PET is also used in "100%-recycled" bottles (actually 90%, allowing 10% for color concentrate) made by Johnson Controls Inc., Novi, Mich. The company, which developed the Scrub-Rite bottle for Amway, says it initially had a stress-cracking problem. The solution was a proprietary drying technique that economically achieves 0.02% moisture in the flake. Johnson Controls says its recycled PET bottles meet the same specs as virgin. As a source of PCR, Johnson Controls uses custom PET bottles and beverage bottles and tries to hold a consistent I.V. around 0.74-0.75.

Continental PET Technologies Inc., Florence, Ky., recently developed a three-layer PET preform with recycle in the middle, aimed at food applications (see *PT, June '93, p. 82*). It also suffered initial stress-cracking problems. One solution, developed by preform specialist Alto Plast in Richenburg, Switzerland, is not to bring the recycled layer all the way into the neck. Instead, higher I.V. material is injected in the neck area.

Many blow molders also make 100%-PCR HDPE flower pots.

I.E.M. Plastics Inc. in Reidsville, N.C. (div. of Resource Recycling in Rockingham, N.C.), blows eight pairs of pots at a time, then cuts apart the Siamese-twin pots. I.E.M. used post-industrial scrap until late 1991, when it began using detergent-bottle copolymer with 5% carbon black as a uv stabilizer. Sales manager Michael Ussery says PCR shows less variation in MI and density than the firm's previous post-industrial resins did. I.E.M. estimates it uses 12 million lb/yr of PCR and is expanding its in-house recycling next year to 16 million lb.

Another blow molder of flower pots and waste containers, Zarn Inc. in Reidsville, N.C., is also vertically integrated. Zarn (now owned by French recycler Plastic Omnium) makes three grades of recycle in-house, screened 60, 80 and 100 mesh.

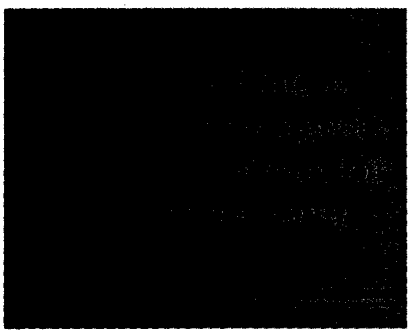
Personal-care bottles are an emer ing application for PCR blow molder which involves extra complication Molders are seeking FDA approval f this application, which requires doc mentation of every step of the recyclir process—in cluding pos tive sortin of post-co sumer bottle singulating them for inspe tion and hot was ing.

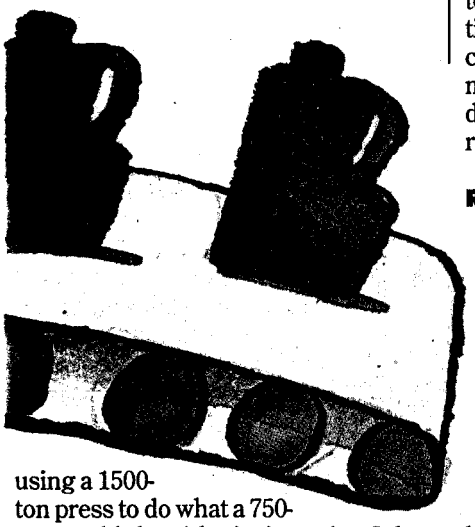
PCR INJECTION MOLDING: SKIMPY

One of the few injection molde applications for recycled resin is Reuter Manufacturing in Hopkin Minn. Reuter uses structural-foa injection molding (with nitrogen-ga injection) to make large HDPE refus and compost bins with 25-75% PCR co tent. To keep costs down and save heat history (maximizing properties Reuter uses detergent-bottle copolyme and milk-jug homopolymer flake, n pellet. "Once in a while, we add an odo izer, one or two drops in a fine spra to kill the sour-milk odor," says manu facturing manager Daniel Roy.

Another injection molder make bins from 100% detergent-bottle copol mer. Milwaukee-based Poly-Anna Pla tic Products Inc., pelletizes its recyc first, using screen packs as a final clea

ing step. President Marty Forman allows that injection molding 100% blow-molding grade PCR is tricky: "You've only got three things to play with—time, heat and pressure." So he opened up the gate diameter and increased injection pressure and clamp force,





using a 1500-ton press to do what a 750-ton could do with virgin resin. Other solutions include multiple gates, raising the melt temperature, and reducing mold cooling time to keep the molds warmer, Forman says.

Rubbermaid Commercial Products Div. in Winchester, Va., injection molds bins using a minimum of 20% LLDPE recovered from stretch film. Rubbermaid initially tried bottle-grade PCR, but couldn't get over 10% PCR content without compromising low-temperature impact strength. Since its trash bins sit outside in winter, this was an important problem. Rubbermaid already uses butene-copolymer LLDPE injection grade, so LLDPE stretch film is compatible with its process, and the material is familiar to machine operators. Stretch film can be made of hexene or octene copolymer. Rubbermaid says there is no problem in mixing the two, though some other processors separate them. And although some stretch film contains PIB tackifier, Rubbermaid has found that normal slip and antiblock levels prevent any problems of sticking. In fact, Rubbermaid is planning a fall introduction of trash-can liners containing a target of 50% post-consumer stretch wrap. (Some other recyclers try to keep stretch-wrap content to a maximum of 25% in order to avoid the cost of adding slip and antiblock.)

Injection molding of any PET can be difficult, and recycled PET is no exception. Recycled PET frequently sticks to molds and won't release unless the temperature is just right. Polymold Inc. in Loveland, Colo., has devised a technique that involves a longer cycle time and chilled molds, so PET parts can cool adequately. Polymold injection molds thin "sneaker balls," shoe deodorizers, using a blend of virgin and recycled PET and elastomer.

ROTOMOLDING: FACT OR FICTION?

Rotomolding is said to be virtually impossible with post-consumer bottle HDPE because its fractional MI doesn't have the right flow properties to produce a good part. One molder that says it rotomolds with PCR, Coon Manufacturing, uses a different material. Coon collects post-consumer injection molded bread trays and food buckets, has them ground and washed and then sends them to be pulverized. Owner William Coon says he rotomolds about 500,000 lb/yr of this material at 50-100% PCR loadings. Products include a 2-cu-yd, 100-lb trash container and a 90-lb plastic gaylord. Cycle time is only a fraction longer: 32 min to make a 100-lb part with PCR, vs. 29-30 min with virgin. This is because it takes a little more time for PCR powder with 3-5 MI to melt than for virgin at 5 MI. Coon says it's still important to use PCR only in a part that you're going to cut open after molding, so you can inspect the inside surface quality.

PCR IN FLOW MOLDING

Flow molding or casting is being used to make some unusual PCR building products. United Resource Recovery, a landfill and material-recovery facility operator in Jonesboro, Ark., for instance, spent two years developing a unique paving-stone product, which consists of recycled HDPE embedded with pebbles, giving it the look of conventional cement paving stones at a fraction of the weight.

United Resource says its patented process is "like rotomolding, but done with flake, not powder." The company uses detergent-bottle and milk-jug flake and reprocessed film, requiring an MI of 0.5 to 0.9. It blends three parts washed flake and two parts unwashed flake to save cost. "When we tried using all unwashed flake, the paper content was too high. The paper burned and the paver wasn't a pretty color. Pavers with too much paper also tend to bow and get an indent in the middle," says United Resource's owner Marcel Jasinski.

DuraTech Industries in Lake Odessa, Mich., does make 100%-recycled product entirely of unwashed flake, leaving in the paper labels. DuraTech flow-molds park-bench ends, taking baled mixed bottles, removing PP caps, color sorting, and grinding in-house.

'DON'T BE SCARED!'

Processors using PCR say the biggest challenge is redefining expectations. With virgin resin, very precise process control is possible. With PCR, it isn't. It takes a lot more work, more in-plant control and monitoring and often longer cycle times. "Now you're taking bottles from 3000 communities across the U.S. and putting them all together. You have a much more generic melt index. There's a whole new comfort factor," says Owens-Brockway v.p. and business unit manager Edward White.

Mary Jarrett, owner of Amazing Recycled Products, a start-up firm in Denver, Colo., that markets only recycled-content products (including the Sneakerball from Polymold) has a can-do attitude toward the challenge. She has nudged several custom injection molders to use PCR in products made for her: "When we help injection molders, we say, 'We know it's complicated to use PCR. But we can get you help. Don't be scared. We've got other plants doing it.'" □□