Herbold Meckesheim GmbH

Production of PET-Flakes
Processing steps for better quality

Siegfried Engel

PET-flakes made out of PET bottles have become an important raw material for some polyester processing industries. Fiber mills, manufacturers of thermoforming sheet, producers of strappings purchase important amounts of PET-flakes to replace high priced virgin resin. But the economic interest is not often meeting the quality requirements of the industries.

The use is limited by flakes being not clean and pure enough. Costly additonal sorting or pelletizing is needed. Sometimes only second class products can be made out of the flakes. Bottle to bottle use or food contact must be limited to a very short percentage of high quality flakes produced world wide.

This lecture tries to show some steps to flake quality improvement and hopes to open your eyes for even more profitable use of this secondary raw material in the future.

1. The basic treatment

To produce commercial PET-flakes you need little: waste bottles, hand sorting, a conveyor belt, a granulator, a swim-sink tank to remove polyolefins and a dryer. This is the basic system and it works.

Let us look into this basic system in detail: the bales are hand sorted, wrong colours and bottles visibly made of PVC are taken out by hand. A granulator (picture 1) with a screen of 12 or 15 mm makes size reduction.

Pict. 1

Pict. 2

The material is led to a swim-sink tank (picture 2), where the Polyolefins (caps, labels) swim and the PET sinks. The sink fraction is removed from the bottom of the tank and dried in a centrifuge (picture 3) or a hot air dryer.

If the machines are of good quality and good function the process ends with flakes that have a commercial value on the international markets and are easily sold. But the price is not very high and the quality is not
very good. The flakes contain residual paper and film coming

from the labels, the flakes contain foreign plastics (especially PVC), the flakes contain metals (especially aluminium). Some glue of the labels is still in the flakes.

Pict. 3

2. How to remove paper

There are different ways to remove paper.

Pict. 4

2.1 Air sifting

After size reduction the dry material is processed by an air sifter. The very light particles in this material, the paper chips and film chips from the labels are removed by an airstream. The heavier particles, the PET-flakes fall down, do not go with the airstream (picture 4). This separation reduces the paper freight in the PET stream. It makes all following processing easier because only a part of the paper is entering the washing step in the swim-sink tank.

The simple air sifting is not very efficient. Paper attached to heavier PET-particles is not removed, many light and fine PET-particles go with the paper fraction and are lost.

Pict. 5

2.2 Wet grinding with friction washer

Much more efficient is the wet grinding (Picture 5). The granulator is used as a washing machine. The mechanical action during the cutting, the friction in the cutting chamber of the granulator is an excellent opportunity of adding water and using it for washing during the size reduction process. The result is always convincing. Washing mills that do a bad job are the ones that do not get enough water. We speak about 10 m^3/hr in a closed loop for a 1 ton/hr bottle granulator.

The washing granulator removes dirt from the plastics, removes sugar and other remaining bottlefill. It destroys paper, the paper fibres and other foreign substances go with the washing water. After the washing granulator a friction washer removes the dirty water from the flakes.

This process step is very efficient but there are some points of disadvantage to be reported: the wet grinder transports most of the paper into the water. It needs a powerful water screening and recycling system and creates important amounts of paper sludge in the water recycling system. This sludge has to be taken care of. In many countries it is expensive to dumb.

2.3 Two step size reduction with air sifting in between

You can get all advantages of the wet grinding without the above mentioned problems by combining the three steps dry grinding, air sifting and wet grinding. This is a two step size reduction, the first step dry and with a screen of about 40 mm, the second step wet and with a screen of about 12 mm. And the air sifter removes most of the paper out of the dry fraction before entering the wet grinder.

- it allows the use of a hog shredder instead of a granulator in the first step, a machine that is much more resistant against foreign particles than a granulator.

- it allows additional mechanical pre-sorting steps between the first and the second size reduction step, before the entry of the washing system

- the wet grinder does not only remove paper, there are all kinds of impurities, sand, sugar, dirt, removed in this early stage of processing.

This all is important if your feedstock is contaminated by metals, stones, glass, paper and polyolefines. First a strong shredder, second additional pre-sorting between and, third, a wet grinder

Our hog shredder (picture 6) is both, a shredder and a granulator. It uses knives and makes a clean cut like a granulator but its knives are blunt, much more resistant against hard foreign particles like stones, glass and metal, like the knives of a shredder. This reduces the cost of blade wear and downtime for blade change

The additional pre-sorting between the two size reduction steps allows the removal of heavy and light foreign particles .A heavy fraction like metals by magnets. Glass and stones by screening machines and other separation equipment. And a light fraction by the use of an air sifter (picture 4) between the shredder and the washing granulator removing paper and plastic labels from the pre-cut Polyester bottles. This is a cheap and efficient way to reduce the burden of paper and film introduced into the following washing part of the recycling line. And thus considerably increasing the efficiency of all following washing steps.

Pict. 6

3. How to remove foreign plastics

The removal of foreign plastics is possible in different ways.

3.1 before size reduction

- by hand sorting, the most simple way and – in countries without high labour cost – the most economic way

- hand sorting under black light makes it easier to see PVC bottles and to do better hand sorting

- electronic detection by NIR camera and automatic sorting by air jets, the most economic way in high labour cost countries. This method needs very efficient debaling before, 100% of the bottles must be individual, no remainings of the bales are allowed.

3.2 after size reduction

- the swim sink-tank, that is already part of the basic system removes polyolefines from the plastics that are heavier than water

- a hydrocyclone (picture 7) does the same job but more efficient if higher throughputs (2 t/hr and more) are requested

- electronic detection and automatic sorting of the flakes at the end of the line, a
- very costly method

Pict. 7

4. How to remove residual film and fibres

Whatever you do in the entry of the line, you can not remove 100% of the paper in this early stage. A certain amount of paper fibres will remain in the flakes through the whole washing and drying process until the end of the line. A small amount, but still paper fibres. This last rest of paper can be reduced considerably by an additional air sifting step. This would remove most of the residual fibres, the fines of PET and most of the residual label film particles.

We use for this purpose a double air sifting device, a combination of a zigzag sifter and a whirl wheel sifter. After the sifter the flakes can be bagged for transport.

A point that is often forgotten: The water circuit, the system to recover the washing water in the line plays an important role in the reduction of the very last amounts of fibre.

Nobody can afford a washing system that uses only fresh water for the process. There will always be a high percentage of washing water running in loops. To maintain a good washing quality the water in the loop has to be cleaned. Mechanical treatment has to remove some of the contaminations in the water. Screening, sedimentation, centrifugal treatment or flocculation have to take place. This treatment has to be careful enough to stop the return of fibres with the return of the water. The paper fibres removed in the first steps of the washing line have to be removed from the washing water before it returns into the system.

5. How to remove glue

They main tool to remove glue is a hot wash step (picture 8). Hot water (up to 90 degrees C) plus detergents dissolve most of the glue. The glue is going with the hot water.

There is a wide variety of glues, more or less nice ones. Somme will swim in water, some will sink. Some will get dissolved in cold water, some in hot water, some only in hot water plus detergents. Some not at all. I have the impression that in Europe the amount of glue is decreasing. For many reasons the soft drink manufacturers reduce the amount of glue used for each label. And shrink labels do not need glue at all.

The hot wash step is an important economic factor. It needs additional water, additional energy and detergents. It increases the cost of recycling PET bottles considerably.

We use two preheating tanks, both working batchwise. One is filled from the size reduction step of the line while the other being full is emptied into the turbo washer. The turbo washer is using caustic soda (NaOH) plus special chemical detergents. At the exit of the turbo washer the hot water containing the glue is separated from the flakes by a centrifuge.

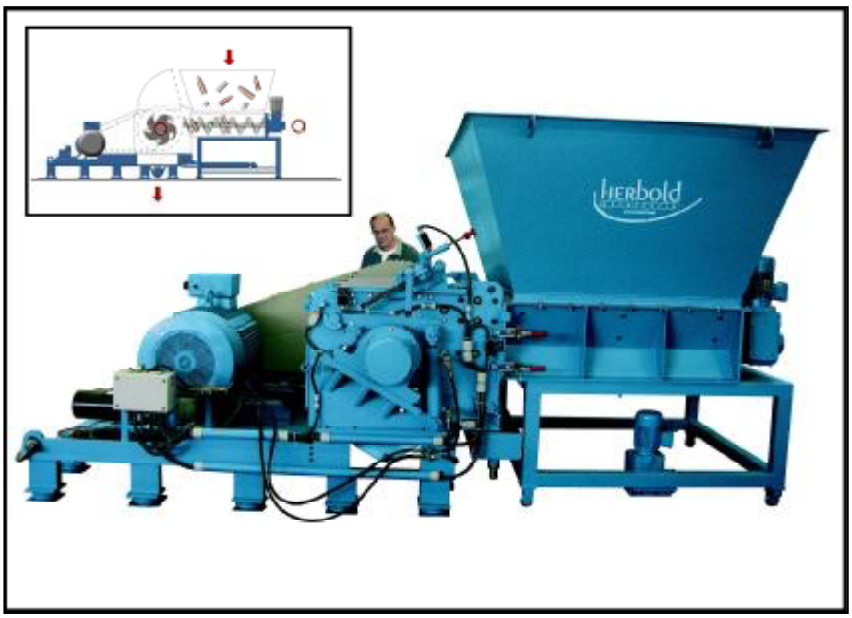
The flakes coming out of the turbo washer and its centrifuge still contain a lot of residual water, caustic soda and detergent. To remove this residues the flakes need careful rinsing in fresh water. If this rinsing is not done very careful you will have red, brown or yellow colour in the flakes after the first melting.

The hot water with caustic soda needs its own, separate water circuit. The glue has to be removed from the water, the fines have to be taken out, the refill of caustic soda and detergents has to be done.

The water treatment in the hot water circuit is one of the key elements in a hot wash line. If it is not well done there will be no high quality flakes produced any more after one or two hours of operation. Unpleasant elements like glue or fines will accumulate in the water. No rinsing device is able to remove all of it. The flakes remain dirty. This point is so important that some manufacturers of hot wash lines do not use recycled water at all. They use 100% of fresh water for the hot wash step. But this makes tremendous energy costs for normal users. If you have cheap heating power, this would work best.

6. News

Some weeks ago I have added a video to this lecture. It presents a new size reduction machine. It is a granulator with forced feeding by 2 or 3 horizontal screws (picture 9) This is new. The traditional granulators are fed by gravity, the bottles are conveyed into the hopper, the rotor takes them or not.



Pict. 9

You often have very low motor load, very low throughput and one has to change the knives frequently to maintain at least a medium rate throughput. This is different now, we have better throughput up to 100 %, a higher load on the motor, longer blade life and all in all less energy cost per pound of flakes, less wear cost and a higher throughput with a given amount of Dollars invested.

7. FILM / VIDEO

Production of PET-Flakes - Processing steps for better quality, Siegfried Engel, Herbold Meckesheim GmbH, Germany, www.herbold.com