Complete Process flow chart of waste PET Bottles recycling into Manmade fibre

1. PROCESS DESCRIPTION

The key point of post-consumer PET bottle recycling is the removal percentage of impurity which is mixed in the duration from beverage factory to recycling plant. The design concept of our different functional processes is to set up the best environment for separating impurities.

Process flow chart of washing line section:

2.1 Functional Section and Machinery

A. De-baling

After the PET bottle bales are placed on the feeding belt conveyer, the balingwire should be cut and removed manually. The bottle bale will be loosedby powerful rolling paddles. And then all bottles will be conveyed to next machine.

B. Bottle Prewashing Section

Under powerful stirring, the continuous bottle washing machine which combined the power functions of machinery, chemistry and

heat energy will separate and remove over 90% impurities (including environment polluted substances and labels, but thermal shrinkage PVC labels excluded). Afterwards process equipment will be protected properly due to purified bottle bodies. Especially the crusher will less suffer because of those hard solid substances were removed.
A dry trammel can be added to do try bottle prewashing to remove most of the solid objects from the bottles surface to reduce the chemical and water consumption of .bottles will be conveyed to next machine.

C. Label Separating Section

There are many types of label used for covering bottles. Most labels will be removed in bottle prewashing process except the PVC labels which is formed by thermal shrinkage. The PVC label scrapping machine is used to tear PVC labels and other plastic labels, and broken labels will be separated from the PET bottles by pneumatic power in Label blower.
The bottles with PVC label will be separated by the PVC bottle sorting machine, People will pick out the PVC bottle by hand, and the PVC label bottles will go to the PVC label scrapper, and then the labels will be removed in the label blower.

D. Bottle Sorting Section

There are two kinds of bottle sorting in the system.
One sorting is done by optical sorting. The NIR technology is used to do polymer sorting, color sorting can be processed by CCD or Visible light technology. The detected objected would be ejected by nuzzles with high press air.
The other is to do sorting manually as final bottle quality inspection before it goes to crusher. The requirement of the labors can be adjusted according to the input bottle quality.

E. Metal Separation Section

Metal separation can be processed in different process.
1. A strong magnetic separator can be hang over the belt conveyer, the ferrous metal would absorbed to the magnetic separator, it could be auto discharging for metal or manually.

2. The bottles would be lay on the moving belt conveyer with metal detector, the bottle and metal would be discharged by a three way flap. One more step on the sub-line would recover the bottles discharged with metal.

3. Metal detector would be installed on the sorting conveyer to prevent any metal going to the crusher. Sorting person can find the metal and pick it out if the conveyer is stopped by metal.

4. A Metal separator is installed to remove all metals before packing, the nuzzles with high press

Air would eject the metal with some flakes when metal is detected by high sensitive metal detector.

F. Wet Crushing Section

This Section is specially designed for crushing PET bottles, which have following characteristics: input smoothly and output stably, low power consumption, low noise and vibration, strong structure, low maintenance cost. It's designed by a wet grinding way.
It can be designed for two steps grinding or one step grinding.
If need to 24hour non-stop running, one crusher would be designed for standby.

G. Flotation & Friction Washing Section

The crushed flakes are mixed with Polyolefin's material; this section is using the gravity difference of PET (~1.3) and Polyolefin's (~0.9), and water (gravity 1) as a media to let PET sink and Polyolefin's float

on the water. This effective will make PET more purified, and collected Polyolefin's flakes can be sold as by-product. With chemical, friction and heat power, the glue will be entirely separated from flakes. The horizontal centrifugal dryer will remove the glue, mud from the flakes.

H. Rinsing Section

After the centrifugal drying, some chemical is residual on the flakes surface. The fresh water would be added to rinse the flakes to reduce the caustic content and give natural PH value of the flakes. In the meanwhile, any floatable material would be removed with the overflowing water.

I. Drying, Mixing & Packing Section

High speed mechanical dryer is used to remove most of the moisture on the flakes surface, to achieve lower than 1% moisture, a hot air conveying system is required to remove the moisture.
To homogenize the impurities and get a higher acceptable product ratio, the mixing silo is to blend and store flakes. Mixing is done by an internal screw.
With a vibration system, 20% packing cost and transportation cost can be reduced.

J. Dust Separation & Optical Sorting Section

Because of weight difference, the air going up from the bottom would take away the dust, light material and a cyclone would collect the dust and light material. Flakes would go down because of gravity. To achieve extremely low impurity content, optical sorting can be installed after drying section to eject color PET, non-PET as well as metals.

G. Process Water and Chemical Solution Circulation Section

Fresh water is applied at the final rinsing machine only. The water would be used to do second or more rinsing to remove the chemical residual and floatable material. Then water would be applied for floating separator and crusher.
Extra water can be used to prepare the chemical water for hot washing and bottle prewashing.
One set of sludge removal system each for bottle prewashing system and flakes washing system is configured to reduce to chemical consumption in the line. The sludge and powder would be removed by machines which are discharged from the centrifugal machine

Spinning description of equipment and process

1. This line uses PET bottle flakes recycled as raw material to produce polyester staple fibers
(Hereinafter called as “the fiber”) by means of dryer, melting by screw extruder, melt filter,

Metering, spinning as well as quenching, finishing, yarn guiding, drawing-off, feeding and filling to
Tow can, and then spun tow yarn is sent to fiber line for production.
This line consists of main production line, auxiliary production units and general utilities.

2 Equipment description

Spinning equipment mainly consist of dryer, screw extruder, melt filter, spinning beam with
Insulation enclosure, HTM circulation system, metering pump and its drive, spin pack, quenching,
Taking-up, drawing-off, sunflower rollers and can traverse..

Process description

In spinning line, PET bottle flakes are dried, then melted and spun into tows.
PET bottle flakes are fed into screw extruder by meaning of melted, mixing and filtering from dryer after
Being dried. The melt coming out from the extruder goes into spin beam through melt filter.
The melt goes into spin beam, in which the specially-designed distribution piping system
Guarantees same dwell time and same pressure drop for the melt to reach each spinning position.
The pin valve fixed before each spinning position ensures individual opening and closing of each
Spinning position.
Each spinning position equipped with one set of high-precision metering gear pump to provide

continuous melt in high pressure and accuracy into spin pack. The metering pump is driven by a synchronous motor with rotary speed controlled by its own inverter. The drive is installed vertically.

There is filter screen and filter sand equipped inside spin pack, which remove impurities from the melt.

The spin beam and melt filter is heated by Dowtherm-A (VP-1). HTM generator (Dowtherm-A vaporizer) is heated by heat transfer fluids (TH66). The specially-designed Dowtherm-A vapor circulation system ensures uniform temperature on each position. The control instruments of Dowtherm-A evaporator have protection function of temperature, pressure and liquid level with safety and reliable.

The melt becomes small stream after being extruded from micro-holes of spinneret and are cooled and solidified by air flow after passing through a low-damping quenching. The melt stream sprayed from spinneret become plastic shape monofilament in very short time and the structure is changed.

This changing is mainly influenced by velocity evenness of air flow from quenching. Air blowing gap, air temperature and humidity, air velocity and flow steady under high velocity affect the direct factor of yarn quality. Therefore, it requires air flow from quenching with stability, uniformity and adjustability.

The cooled and solidified filaments are oiled and damped by oiling device to increase the cohesion
of the yarn, to improve the antistatic property of the yarn, to reduce the friction between the yarn
and the yarn, and also to reduce the friction between the yarn and equipment, and to improve the
after-treatment property of the yarn.
The yarn end threading is operated manually by suction gun. After passing through oiling device in take up, the yarn from every position is guided by godet roller
to the end of take up unit and is entered into drawing-off roller, then is fed into Tow Can by
sunflower rollers. The drawing-off rollers and sunflower rollers are driven by synchronous motor.
The engaged depth of two sunflower rollers is adjustable. The drawing-off rollers and sunflower
rollers are with low speed set for yarn string-up and easy operation. Spinning and take-up system
is set with collective communication system.
Can traversing unit is driven by A.C. motors, which realizes to transporting change of empty can,
reciprocating movement of tow can and delivery of laden can. This unit has two kinds of control:
manual (except reciprocating movement) and automatic. When tow can reaches certain weight by
time setting, the programmable-control time counter gives off a signal, then reciprocating
mechanism automatically moves laden can to the center of the unit and delivering mechanism
moves laden can out, in meanwhile, to move in empty can for continuous tow collection. Then the

tow in can will be balanced and sent to after-treatment process.

Process flow of melt spinning

PET bottle flakes → heated and dried → extruding → melt filter → spinning → quenching →
taking-up → drawing-off → feeding → tow collecting (CTU)

Note : Now finished material is moved to next section called as Draw line section

Process description(Drawline section)

The tow creel is arranged for 4 rows, in which, two rows of them are put into using and the other
two rows are preparing. Or four rows are put into using if with LLDPE tow can.
The tows from Tow creel are divided into 3 nos. sheets for drawing. The tow cable come from the
creel is guided firstly by Tow guide frame and passed through DIP bath in order to split tow sheets
evenly with certain width and thickness, and ensure more even spin finish in tow sheets, and then
drawing process starting.
The range uses 2-stage drawing technology. The first drawing stage carries out between Draw
stand I and Draw stand II. The temperature of Draw bath is about 70°C~80°C. The draft ratio of the

first drawing stage is completed 80%~85%. The second drawing stage carries in Steam draw chest between Draw stand II and Annealer-1. The tow sheets are directly heated by spraying steam in Steam draw chest and the temperature is about 95°C~105°C. The draft ratio of the second drawing stage is completed 15%~20%.

After the tow sheets go through the second drawing stage, the tows obtain the full orientation of molecular structure.

The tows drawn are sent into Annealer for drying firstly, then heat setting under certain force to eliminate the residual force in tow sheets due to drawing and to improve the fiber physical performances by means of increasing fiber tenacity and reducing fiber elongation.

After heat setting, the tow sheets firstly go through Spraying unit to get cooled to certain temperature for keeping the fiber performances in stability. In the meanwhile, the final oiling in the tow is achieved herein. Then the tows are dragged and gone forward through Draw stand III.

After cooled and oiled, the tow sheets are sent into Tow stacker, 3 tow sheets are stacked into 1 tow sheet. The tilt angle of stacking rollers is adjustable for achieving stacking process. The width of the tow sheet and the quality of stacking is special important for crimping.

After stacking, the tow sheet is sent into Crimper through Tension control roller and Steam

pre-heating box. The tow sheet is crimped by stuffing box through squeezing to assure the good
performances of fiber in later process.
After crimping, the tows spread to chain board type conveying of Relaxing dryer. The tows are
heated and dried evenly by blowing of forced air and then cooled down below glass temperature.
After heated and dried, the tows are dragged to upper floor for cutting by Tension stand, which also
guarantees the tows under tension evenness to feed Cutter in tangential direction of cutting reel.
The tows are cut into fixing length of staple by adopting press cutting. After cutting, the cut fibers
enter into baler feeding chamber in gravity for baling, then the bale is manual baling, labeling,
reweighing and then sent to the storage by fork lifter.

Process flow (Drawline section)

**Creel → Tow guide frame → DIP bath → Draw stand I → Draw bath → Draw stand II → Draw
steam chest → Annealer (including flash tank system) → Cooling sprayer → Draw stand III →
Stacker and traction → Tensioning control roller → Steam heating box → Crimper → Conveying
and swing → Relaxing dryer →Tension stand → Cutter → Fibre conveyor → Baler → Warehouse**

Quality standard of final product called as recycled polyester staple fiber

S.No. Item Unit PET flakes as material
**1.56 dtex
1 Tenacity at Break g/d ≥6.3
2 Elongation at Break % 20-28
3 Deviation of Titer % □}4.0
4 Deviation of length % □}3.0
5 Over length fibers % ≤2.0
6 Double length fiber content mg/100g ≤ 10.0
7 Crimp number n/25mm 11□}3.0
8 Crimp ratio % 11□}3.0
9 180℃Shrinkage rate % 6.5□}3.0
10 Specific resistance Ωcm (1-10) ×108