EREMA®
PLASTIC RECYCLING SYSTEMS

NOVATEX

NOVATEX LIMITED
STEP

TOWARDS SUSTAINABILITY....

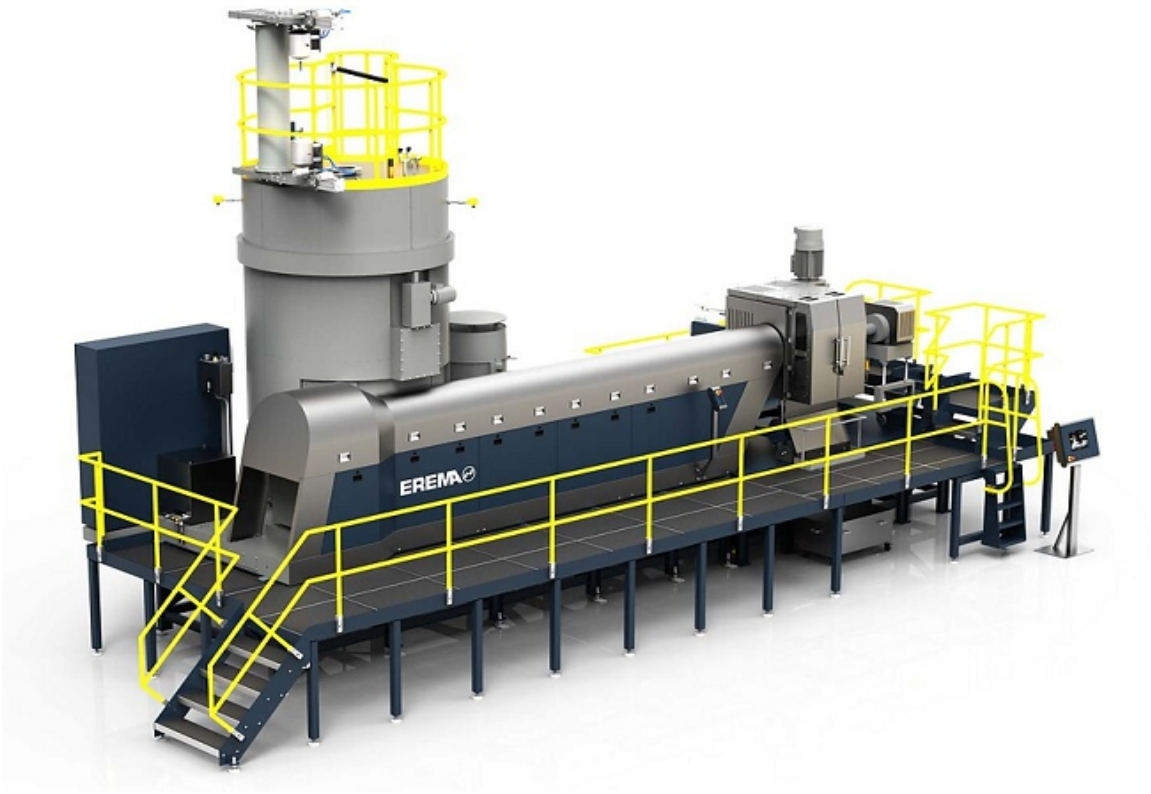
Gatron (Industries) Ltd. and Novatex Limited belong to a group of companies, G&T – Gani & Tayub. The group is in business since 1948. These seven decades of operational excellence, experience and expertise have all formed a combined strength to empower the group as a leading name in Polyester Filament Yarn, Polyester Chips and PET Resin in Pakistan and all over the world.

Novatex Limited itself have 2 polycondensation plants (One, from Zimmer, Germany and other from CTIEI, China) and three solid state polymerization plants (two, from UOP Sinco, Italy and third one from Polymetrix, Switzerland) for its bottle grade resin production. We have been supplying bottle grade resin to Pepsi, Coca-cola, Nestle, Danone, etc, for many years.

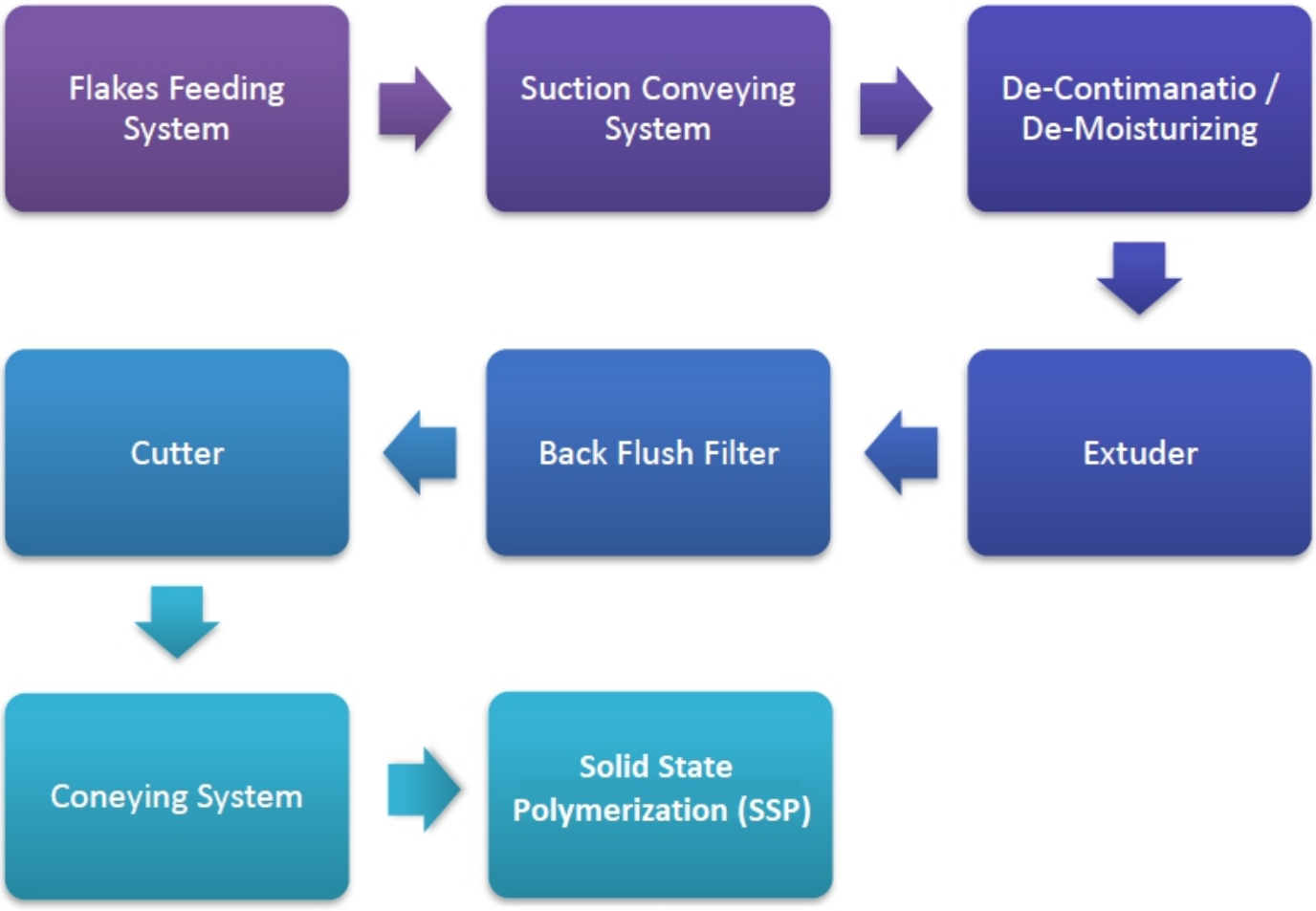
Now we are more concerned about our environment's sustainability and ultimately we have taken a bigger step towards '**going green**' with value addition at its peak and decided to install a **(96 tons / day)** rPET extrusion line (bottle to Bottle technology) from rPET flakes to rPET resin. The main process flow of the recycling technology is defined below.

Novatex Limited have chosen EREMA Plastic recycling systems as their recycling partners.
The systems from EREMA are designed for a single purpose, to make plastics recycling as innovative and efficient as possible. They develop reliable machines and components that are customer and solution-oriented in every detail. For them, sustainable business goes hand-in-hand with profitable processing. At the moment there are more than 6500 of their systems in operation worldwide.

Together they produce more than 14.5 million tonnes of the highest quality pellets annually. These figures make Erema, the world leader in plastics recycling machines and system components.



PROCESS FLOW DIAGRAM:



Flakes Feeding:

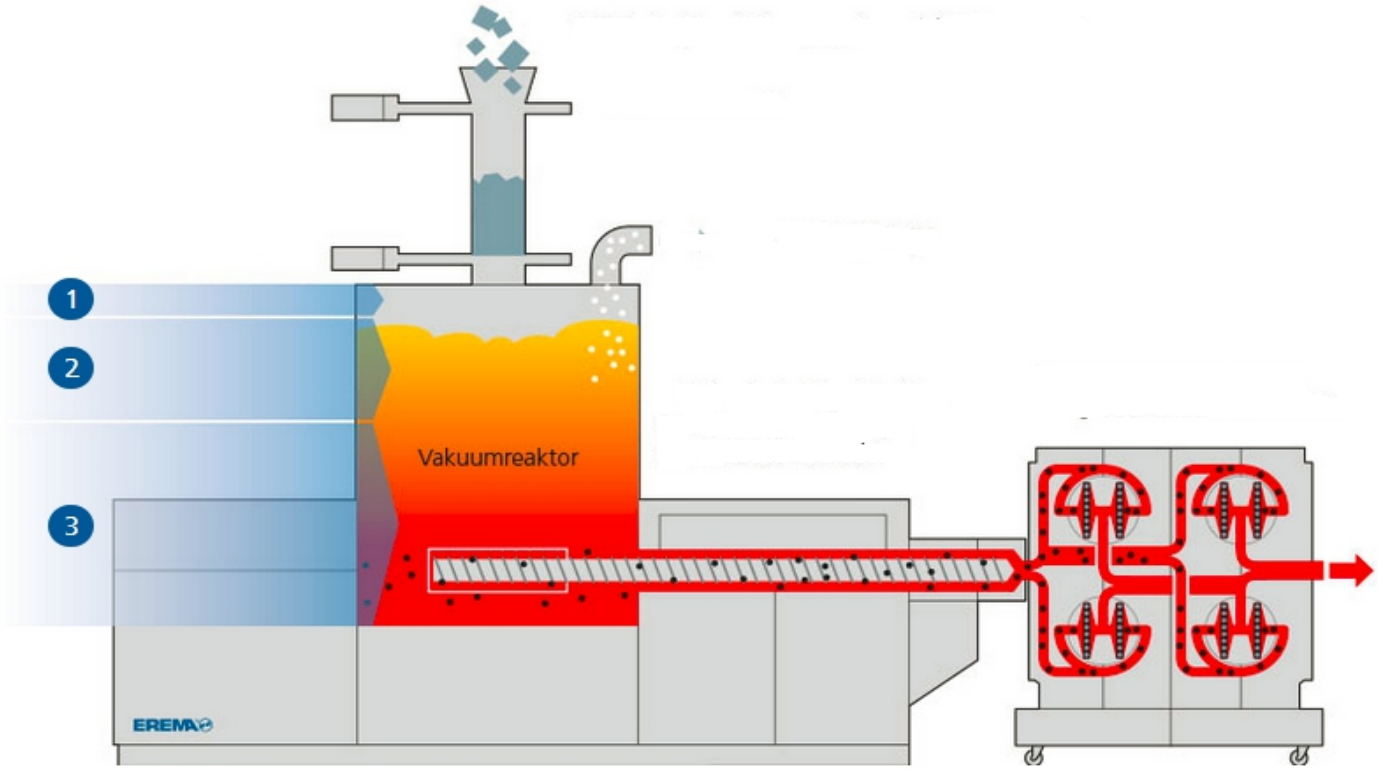
The very first process of our recycling system involves feeding of rPET flakes into our recycling unit. Bottle to bottle rPET flakes are fed into a flakes silo through a primary vacuum suction system (provided by Plastic systems).

Erema Vacuum Suction system:

Flakes are then transferred to vacuum sluice unit of Erema system via a secondary vacuum suction feeding system (Supplied by Erema). These vacuum sluice units, basically, controls the vacuum in the main decontamination reactor by constant feeding of flakes into it.

Decontamination / Vacuum reactor:

The key components of the system is 'a vacuum reactor' which is connected directly to a single-screw extruder. Thanks to the ingenious function of the mixers in the vacuum reactor they feature **three ultra-efficient function zones** which interact perfectly with each other to decontaminate and predry the PET material perfectly already BEFORE extrusion,



Zone 1: is responsible for the removal of the outer moisture of the PET flakes.

The amorphous, washed flakes which enter Zone 1 via a vacuum sluice, still have extremely varying external moisture (between 0.5 and 1%). This is eliminated at around 20°C under vacuum through the reduced vaporisation point (the inner moisture here is still constant at around 0.3%).

Zone 2: Here the temperature rises from 20°C to 190°C.

Thanks to the constantly rising temperature, the polymer structure opens up and the process for the removal of the migration substances and the internal moisture from the flakes begins.

Zone 3: The process of flake decontamination and removal process unfolds with full effect.

The process of flake decontamination and removal process unfolds with full effect. The material moves layer by layer in the direction of the single-screw extruder during the exactly defined residence time. With very low residual moisture of under 0.05% the clean, perfectly prepared material enters the intake zone of the extruder.

Extrusion:

This material transfer takes place under high vacuum. As a result no additional degassing ports are required on the extruder itself. This means that VACUREMA® technology drastically reduces the length of the extruder, reduces its energy consumption, improves the colour values (b value) of the processed material and keeps AA values to a very low level. Moreover, the strong homogenization performance of the extruder plays a significant part in turning the different input IV values into a stable output IV value.

Filteration:

In the downstream **high-performance fine filter** the material is filtered with a 56-60 µm mesh screen width. The filter system is equipped with a patented fully automatic self-cleaning system that enables long filter service life. The melt is now ready and can be transferred directly to the downstream unit.

Under water Granulation (For 100 % rPET):

After filtration, the melt rPET material is then pumped towards a under water granulator (i.e.Cutter), where the molten polymer is quenched by demineralized water and cut via a rotor and then dried by a vertical dryer. There rPET pellets are then conveyed to packing or further processing (SSP) as per plan.

Solid State Polymerization (SSP):

The rPET Resin (100 % or mix rPET resin after molten mixing) is then fed into Solid State Polymerization process (UOP Sinco), where IV of the resin is lifted as per market's requirement and Acet Aldehyde and other hydro carbons are also removed in this process. This process will serve as a secondary decontaminator in our rPET resin success program.

Detailed Unit Description

UOP SINCO's SSP process unit can be divided into five basic process sections:
1) Pre-crystallization and Hot Dedusting Section;
2) Crystallization Section;
3) SSP Reaction Section;
4) Product Cooling Section;
5) Nitrogen Purification Section;

Pre-crystallization and Hot Dedusting Section

The amorphous rPET/PET chips are transported from raw material storage silos to the chips surge silo. rPET/PET chips are continuously loaded into the pre-crystallizer through the rotary valve, where crystallization takes place. Nitrogen flowing in a closed circuit is used to fluidize the chips inside the pre-crystallizer. The pre-crystallizer is operated at ~195 °C. This equipment also performs dedusting operations, removing very small particles- less than 300 microns in diameter. The fluidizing nitrogen is processed through the twin cyclone, followed by the in-line filter to eliminate any entrained dust. The majority of the dust is removed by cyclones and collected by dust collectors. The filter protects the blower against abrasion and polymer deposits by removing any remaining dust.

The nitrogen gas is then recycled to blower and heated from 175 °C to 225 °C by a finned tube heat exchanger. The fluidization of the bed is controlled via the velocity of the nitrogen in the bed. Control of the pressure, temperature and flow are fundamental for the proper operation of the pre-crystallizer. A slipstream of nitrogen from the pre-crystallizer closed-loop is conducted to the nitrogen purification section to remove Chlorine (If PVC content of the rPET resin is higher), acetaldehyde and other hydrocarbon contaminants released during the pre-crystallization step. This scheme regulates the amount of contaminants in fluidizing nitrogen. The chlorine removal from the nitrogen is a new process and added in our existing SSP system just in order to control Chlorine and its adverse effects on our hardware. The dust-free nitrogen sent to the NPU is taken after the filter. The chips exit the hot dedusting and pre-crystallization section through rotary valve positioned above the crystallizer.

Crystallization Section

The dedusted and pre-crystallized rPET/PET chips are fed to the crystallizers through the rotary valve. The two crystallizers completes the crystallization to about 40-55% by weight of the PET fed by performing the heating of chips

from 195 °C to about 210 °C. The machines are heated by re-circulation of diathermic oil supplied by the pumps. The oil flows inside the paddle type screw conveyors and inside the jacket. Process nitrogen, coming from the nitrogen purification unit, after passing filter, removes the fines produced by the screw conveyors and the acetaldehyde released during the heating. This nitrogen together with process nitrogen coming out of the SSP reactor is sent finally to the cyclone for dust separation. After exiting the cyclone, the nitrogen stream combines with the nitrogen in the closed circuit used in the dedusting and pre-crystallization section.

Solid State Polycondensation (SSP) Reaction Section

The SSP reaction takes place inside the reactor at 205-218 °C for approximately 14-18 hours, depending upon feed and product properties, as well as polymer reactivity at operating conditions. The hot PET chips, coming from the crystallizer, are fed to the reactor through rotary valves. The chips flow down through the reactor via gravity. The reactor is equipped with a multipoint temperature indicator and temperature alarms to monitor the reaction and prevent overheating. The reactor is also equipped with a level sensor, which is used in conjunction with a speed controlled rotary valve at the outlet of the SSP reactor.

In this way the chips level inside the reactor is maintained at the desired value. This is also the main control loop employed to control residence time and ultimately the intrinsic viscosity (IV). The nitrogen stream flows upwards, counter-currently to the chips flow. The nitrogen stream removes volatile SSP reaction by products, including acetaldehyde, ethylene glycol, other contamination and water. This stream exits the reactor at approximately 210 °C, is processed through the cyclone, and is then sent to the hot dedusting pre-crystallization section. The hot PET chips are discharged from the reactor through the self cleaning strainer and subsequently to the fluidized bed cooler and deduster through the rotary valve.

Product Cooling Section

The hot PET chips (at 165~185 °C) coming out of the SSP reactor are cooled down inside the fluid bed cooler below 70 °C before being discharged to chips conveying system. Cool Nitrogen from Nitrogen purification unit is blown into the fluidized bed cooler using suction from the blower located at the outlet of the fluid bed.

Nitrogen Purification Section

For optimal performance of the SSP process unit, UOP SINCO's patented Nitrogen Purification Unit (NPU) removes acetaldehyde, ethylene glycol, and other organic hydrocarbons liberated during the reaction in the circulating nitrogen. A catalytic combustion process removes these hydrocarbons; the resulting moisture, generated during the combustion, is removed using molecular sieve type dryers.
The NPU circuit (circulating nitrogen) is comprised of four basic users:

1) Precrystallizer/Deduster
2) Crystallizer
3) Reactor

The nitrogen circulating in the closed loop of the hot deduster/pre-crystallizer is continuously purged by withdrawal of a slipstream to the NPU. Approximately 10% of the flow is sent to the NPU for subsequent purification. The slipstream is taken after the inline filter. A pair of blowers, protected by the self-cleaning filter, are the primary drivers in the NPU circuit. The nitrogen stream picks up heat from exchanger (economizer) and electric heater before entering the oxidation reactor. Hydrocarbons are removed by catalytic combustion inside the reactor using a UOP precious metal catalyst. A precisely controlled amount of air is introduced into the reactor via a control valve. Oxygen and hydrocarbon analyzers provide feedback to the combustion control loop.

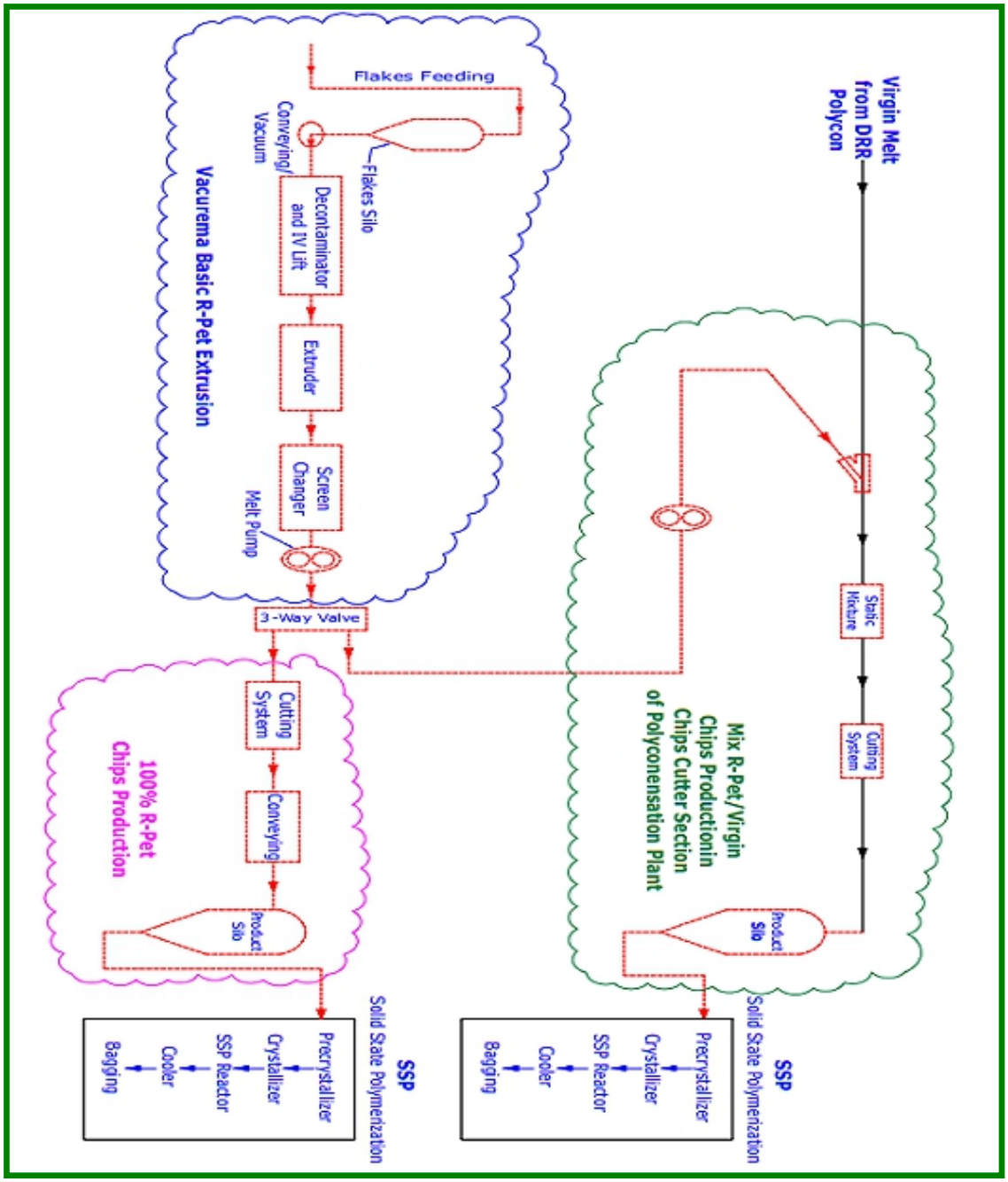
The moisture rich hot gas stream, free from hydrocarbons, passes through exchanger to partially cool before being delivered to the molecular sieve type dryers. The exchanger picks up heat and transfers it to the gas stream entering the oxidation reactor. In this way an optimal conservation of the total heat energy in the system is achieved. A slipstream from the moisture rich hot gas stream, free from hydrocarbons, is sent to crystallizer after passing the crystallizer nitrogen filter. The reaction taking place within the crystallizer favors the humid nitrogen stream. The majority of the moisture rich hot gas stream, originating from the oxidation reactor, is fed to a pair of dryer vessels through cooling exchanger. This exchanger operates with cooling water. The dryers and employ a premium, long life UOP molecular sieve type adsorbent bed. They operate on a 12 hour cycle: while one dries the process stream, the

other is regenerated. For example, the moisture rich stream flows through dryer and subsequently through filter. The stream exiting the circuit is moisture free.

The purified, cooled gas stream is sent to the product reaction section and the hot-lift conveying system. While dryer is in operation, dryer is being regenerated. A closed loop circuit comprising of cooling exchanger, moisture remover blower, HTF heater and the dryer vessel are used to completely remove water adsorbed by the molecular sieves during the previous operation cycle. The re-circulated gas stream is heated to 250°C before the dryer and is cooled to 40 °C after the dryer to condense water removed from the hot adsorbent bed.

VALUE ADDITION: (MIX RPET)

Despite of producing 100 % rPET resin and inducing the customer to mix that 100 % rPEt material with virgin materia physically to get desired mixing ration in injection molding, we have planned to mix the molten rPEt material into our molten virgin PET material, in specific ratios, to get a homogenized rPET mix product from our granulator and then process them in our SSP plant for lifting the Intrinsic Viscosity and further decontamination under influence of hot Nitrogen environment in our SSP. The schematic process flow diagram is shown below:



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