CPT PROJECT

POLYPROPYLENE

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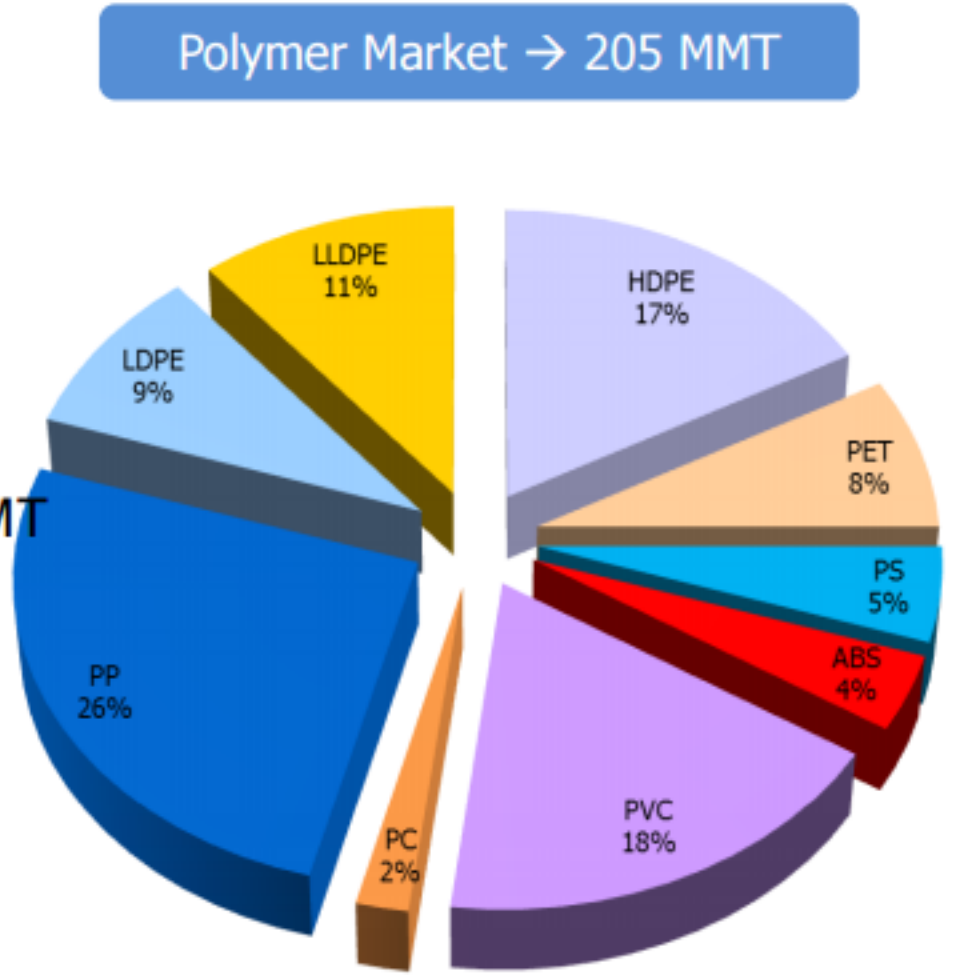
GLOBAL POLYMER OVERVIEW

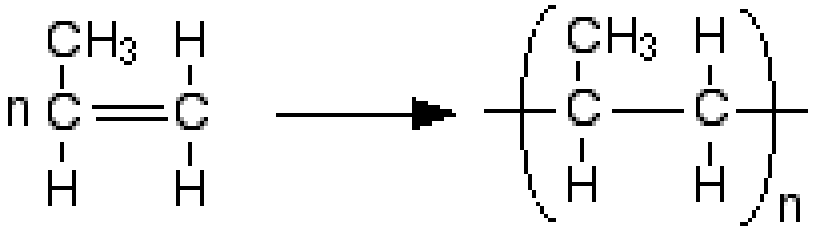
- Polyethylene Market: 75.9 MMT
- Polypropylene Market: 56.1 MMT
- PVC Market: 36.9 MMT



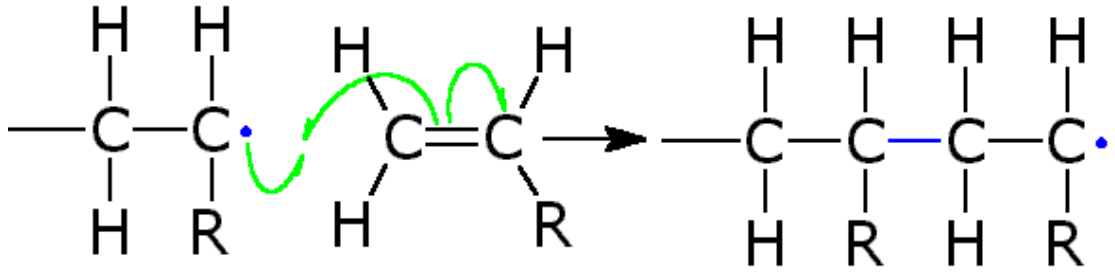
Source: IHS Data, as of 2014

POLYMERIZATION REACTION

Basic Reaction

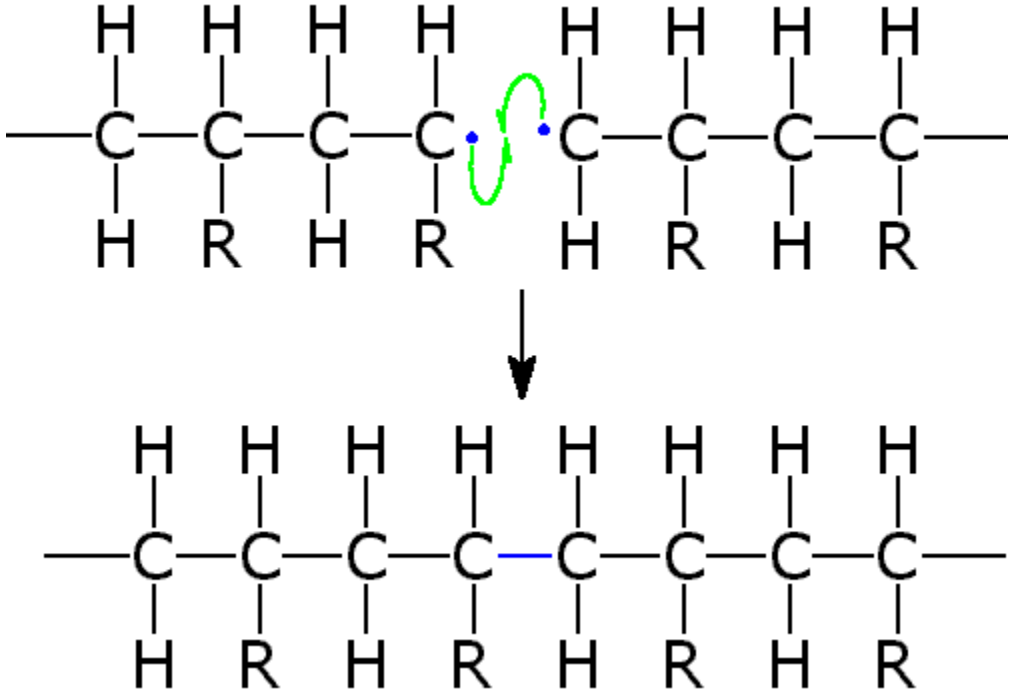


Mechanism



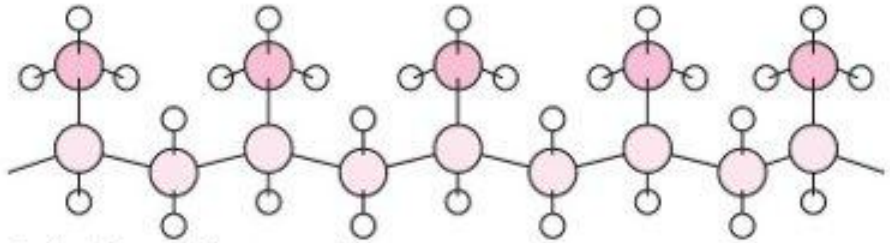
R = CH3

As can be seen the alkene unit is unsymmetrical and therefore has two ends, a head and a tail. The reaction above shows tails adding to heads all the way along the chain.

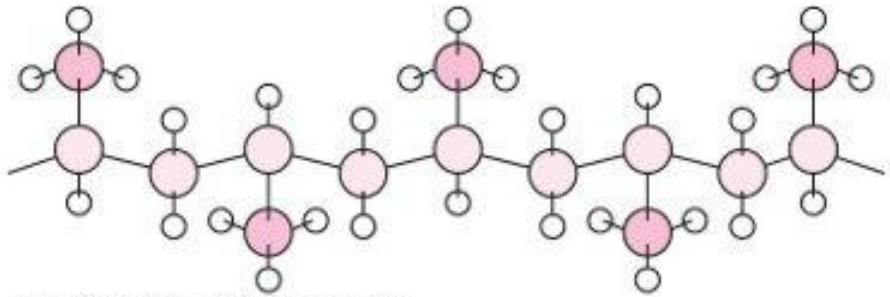


The termination step involves the reaction of any two free radicals together, called combination termination, yielding a new bond and stopping chain growth.

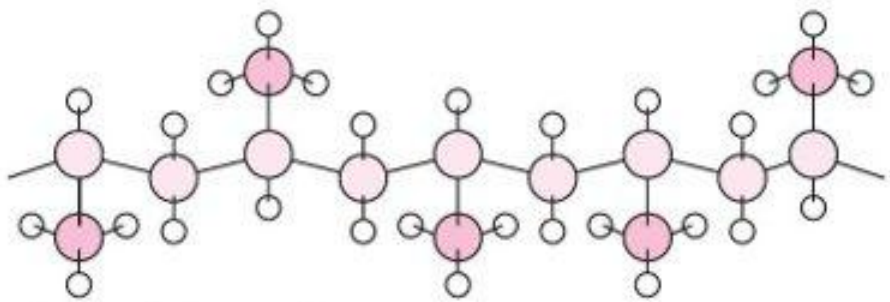
STEREOCHEMISTRY OF POLYMERS



isotactic poly(propene)



syndiotactic poly(propene)

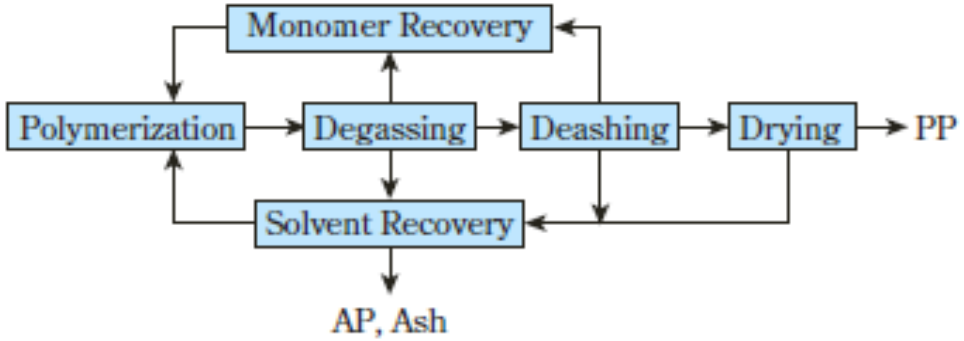


atactic poly(propene)

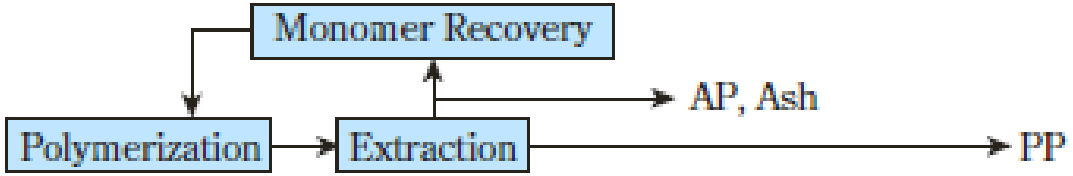
VARIOUS METHODS OF PRODUCTION

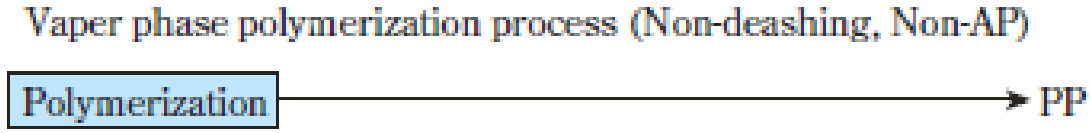
	SOLVENT POLYMERIZATION	BULK POLYMERIZATION	GAS PHASE POLYMERIZATION
Carrier used:	Hexane or Heptane	Liquefied Propylene Monomer	Vaporized Propylene
Inception:	1957	1969	1983
Advantages:	· Heat Removal, as some of the heat is absorbed into the solvent.	· Polymerization reaction is rapid, thus reducing retention time.	· Improved Catalyst Performance · Exothermic Energy absorbed into vaporizing propylene · Impact Copolymers can be formed
Disadvantages:	· AP Removal · Solvent Removal · Contamination of product	· AP Removal · Does not form Impact Copolymers	· Heat Carrying Capacity is lesser than liquid.

1. SOLVENT POLYMERIZATION



2. BULK POLYMEF





3. GAS-PHASE POLYMERIZATION

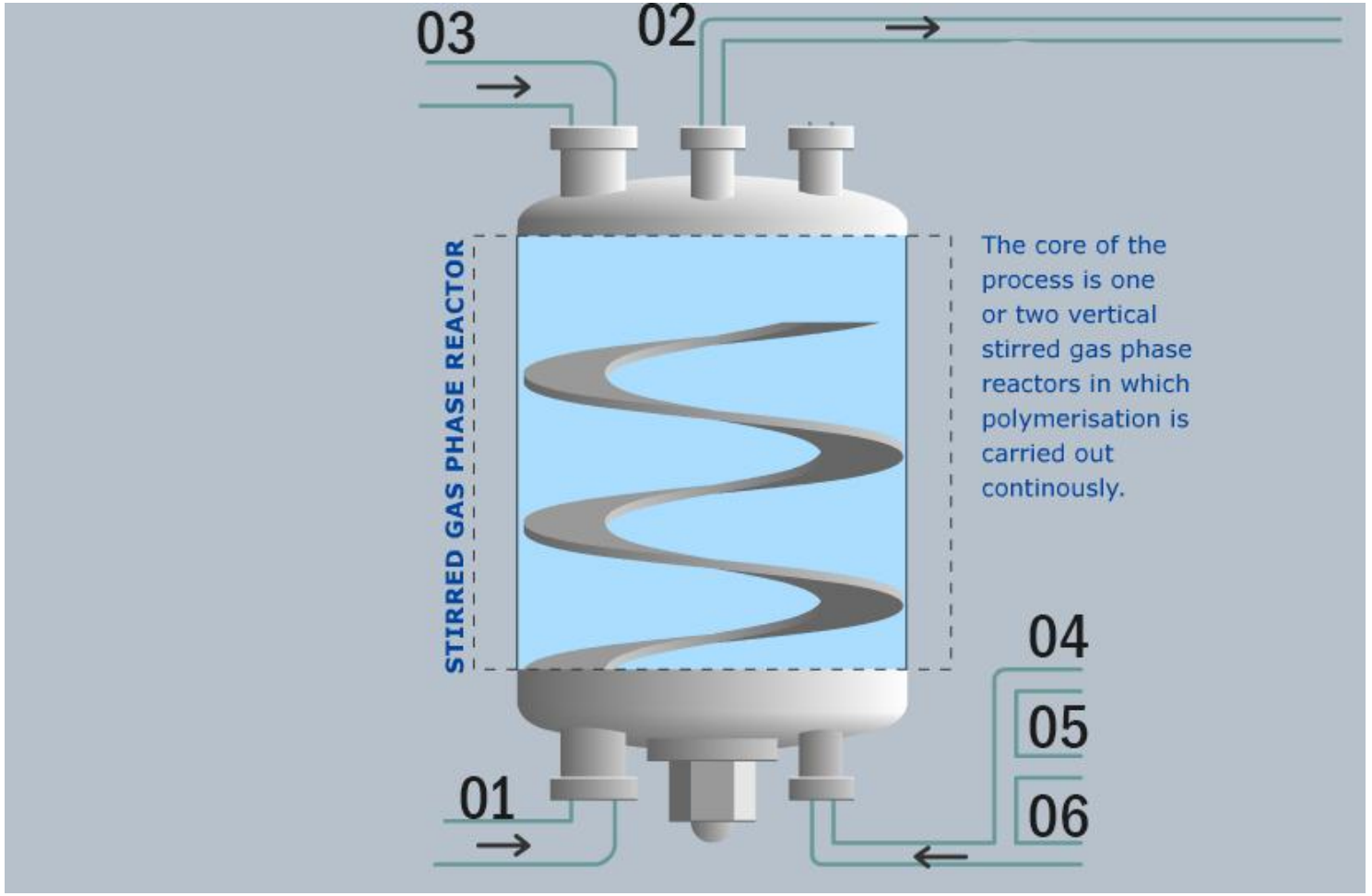
PROCESS SELECTION

The important criteria for selecting the manufacturing process is in terms of availability and consumption of raw materials, plant construction cost, utilities required for each process, operational conditions, safety and environmental issues and production rate.

Since the Vapor-phase production process completely eliminates the need for any deashing equipment and also does not form any undesired product ie. AP, this highly reduces the cost of equipment and handling. Also, the raw material used is propylene in vapor phase which is natural form of its availability.

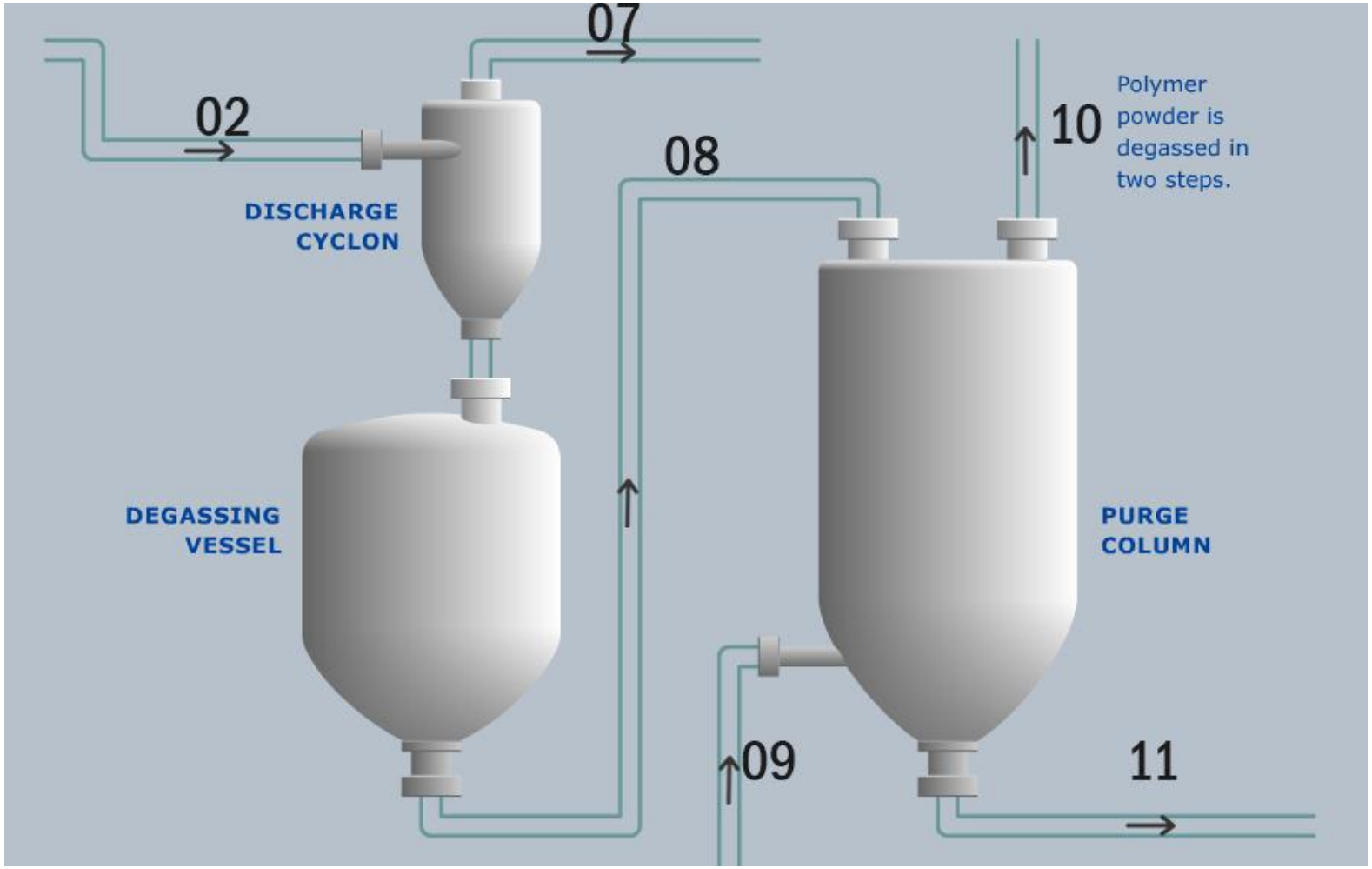
INDIVIDUAL OPERATIONS AND MATERIAL BALANCE

POLYMERIZATION REACTOR



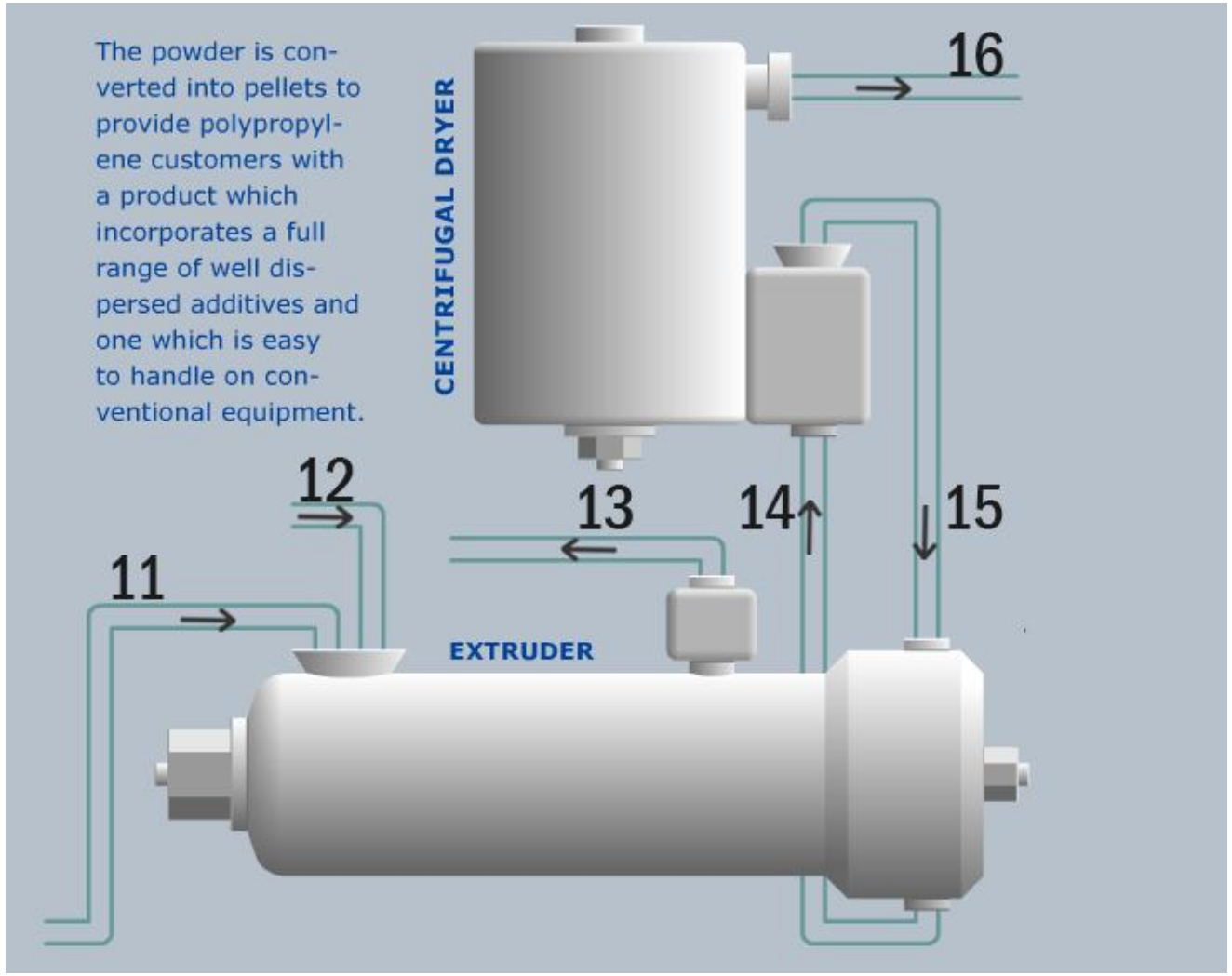
Fresh propylene is fed to the polymerization reactor together with the required catalyst (ZIEGLER NATTA), co-catalyst (TEA), hydrogen and silane. The purpose of co-catalyst is to act as the catalyst activator for the polymerization, using hydrogen to control the molecular mass of the polymer (chain length) and the purpose of Silane is that it acts as a stereomodifier in the polymerization process thus, used to control the balance of crystalline – amorphous polymer in the product.

POLYMER - GAS SEPARATION



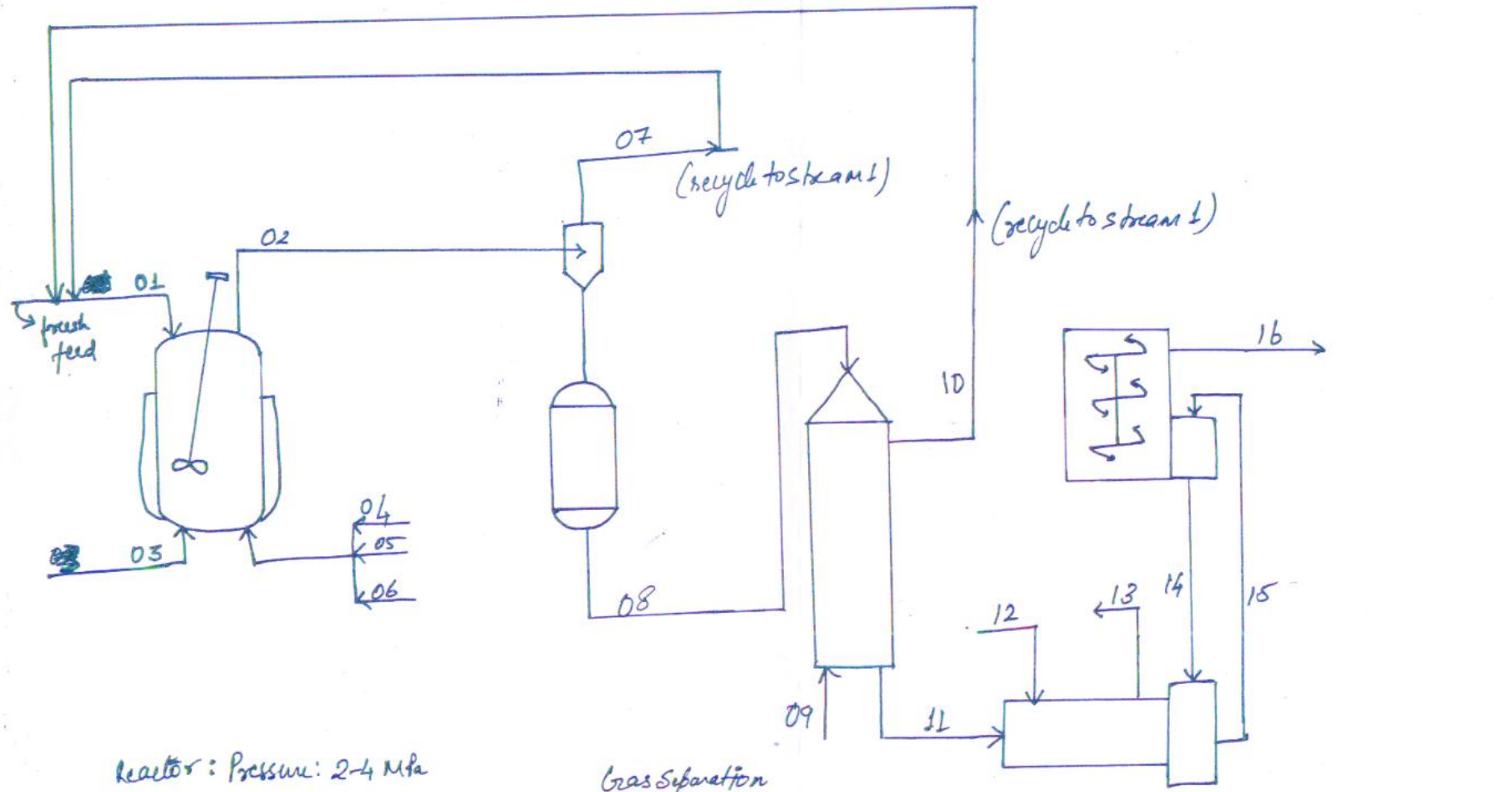
The Polypropylene product powder is then produced and is blown out of the reactor under pressure into the powder discharge cyclone. Its function is to separate between the powder and carrier gas. The remaining carrier gas is then fed to a degassing vessel and a following filter to remove any residual powder. The purpose of nitrogen in the purge vessel is to purge the powder off any residual monomers by nitrogen.

EXTRUSION AND DRYING



Powder product is then fed to the extruder where additives are mixed. Peroxide is fed to the extruder to control melt flow rate (MFR). Pelletizing of the final product is carried out in an underwater pelletizer where the extruded polymers are cut under water by a set of rotating knives to convert the products to pellets. Water and pellets from the underwater pelletizer, are fed to a centrifugal drier where the pellets and water are separated. Water is recycled to an underwater pelletizer. These pellet are then fed to the Drying unit where water and other off gases are removed. From this, the pellets are transferred to the packaging area.

PROCESS FLOW DIAGRAM



Reactor: Pressure: 2-4 MPa
Temperature: 80°C
Efficiency: 83%

Gas separation unit: Temp: 80°C
efficiency = 90%

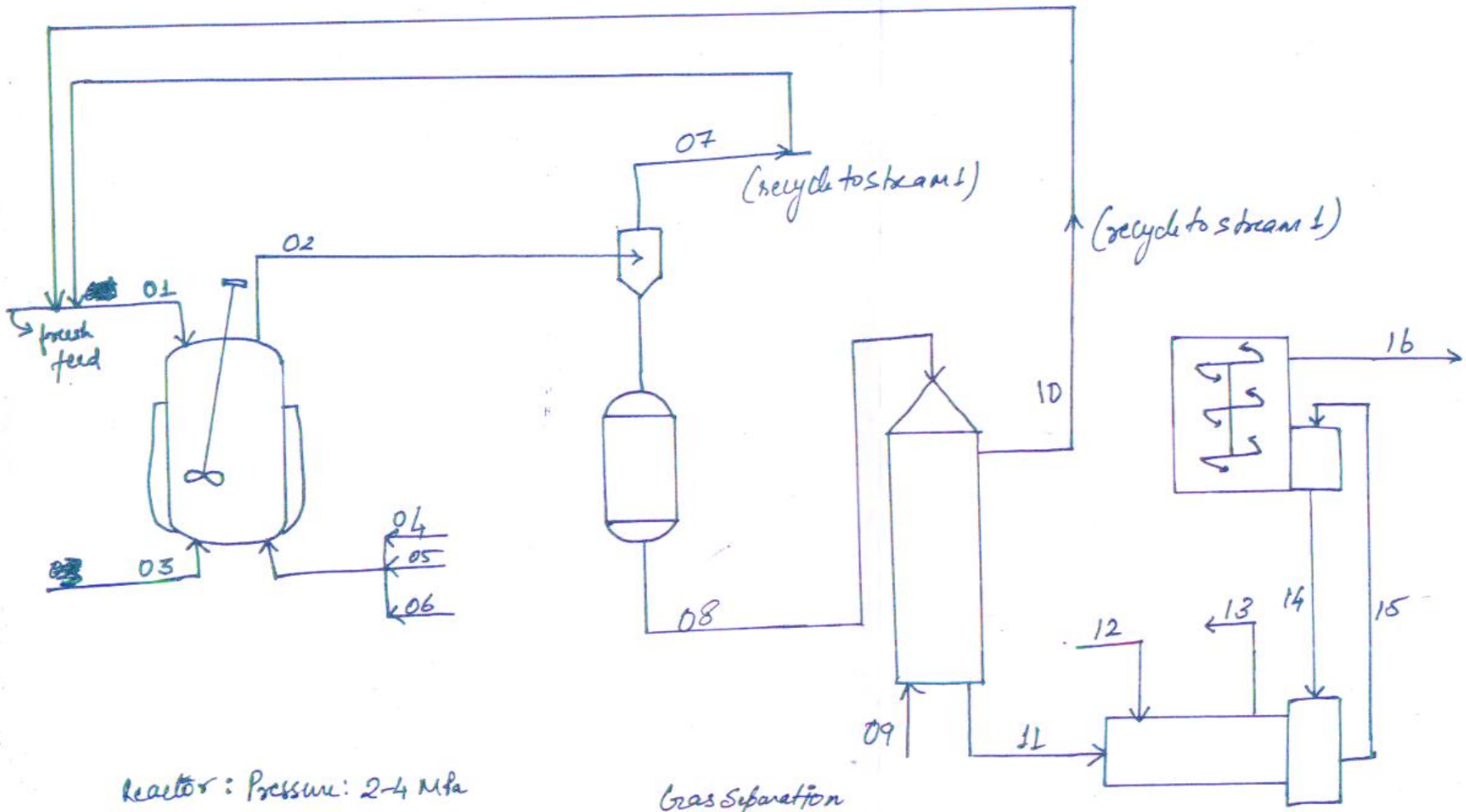
Extrusion unit: Pressure: 60-100 MPa
Temp: 230°C
efficiency = 100%
drier efficiency: 99.99%

References

- Review on Development of Polypropylene Manufacturing Process, Sumitomo Chemical Co., Ltd.
- Energy analysis in the extrusion of plastics, Nana Levi Njobet,2012
- http://www.cbi.com/technologies/novolen-gas-phase-polypropylene-process-description
- http://www.bcplonline.co.in/content.php?pageno=8&pageid=28&SubpageNo=2
- http://www.dsir.gov.in/reports/techreps/tsr082.pdf

Process Equipments

PROCESS FLOW DIAGRAM



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Stirred Gas Phase Reactor

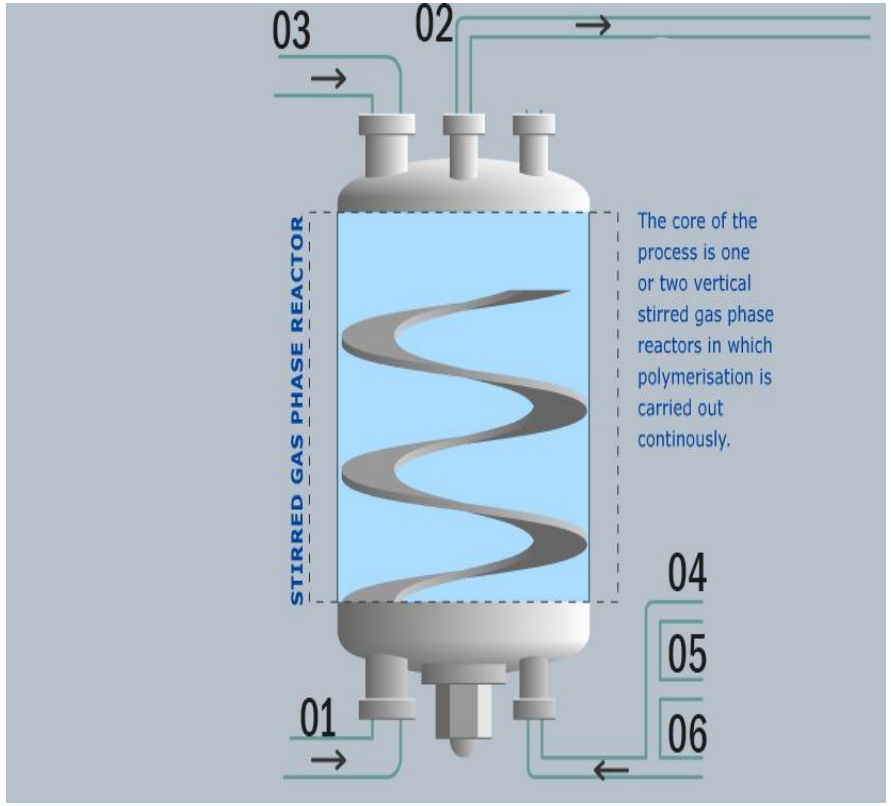
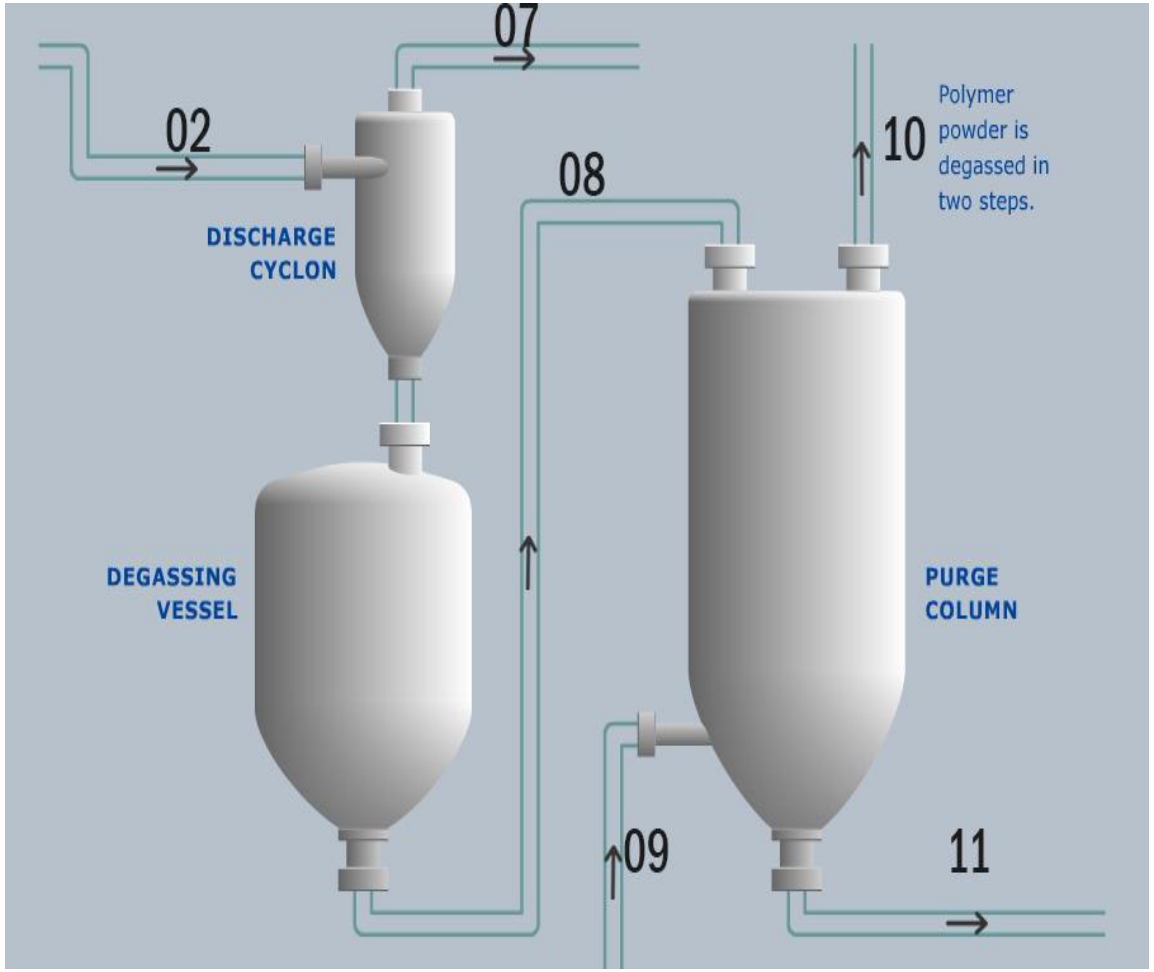


Image courtesy : Enviropro UK

POLYMER - GAS SEPARATION UNIT



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Cyclone Discharge

Image Courtesy : AIREX Industries

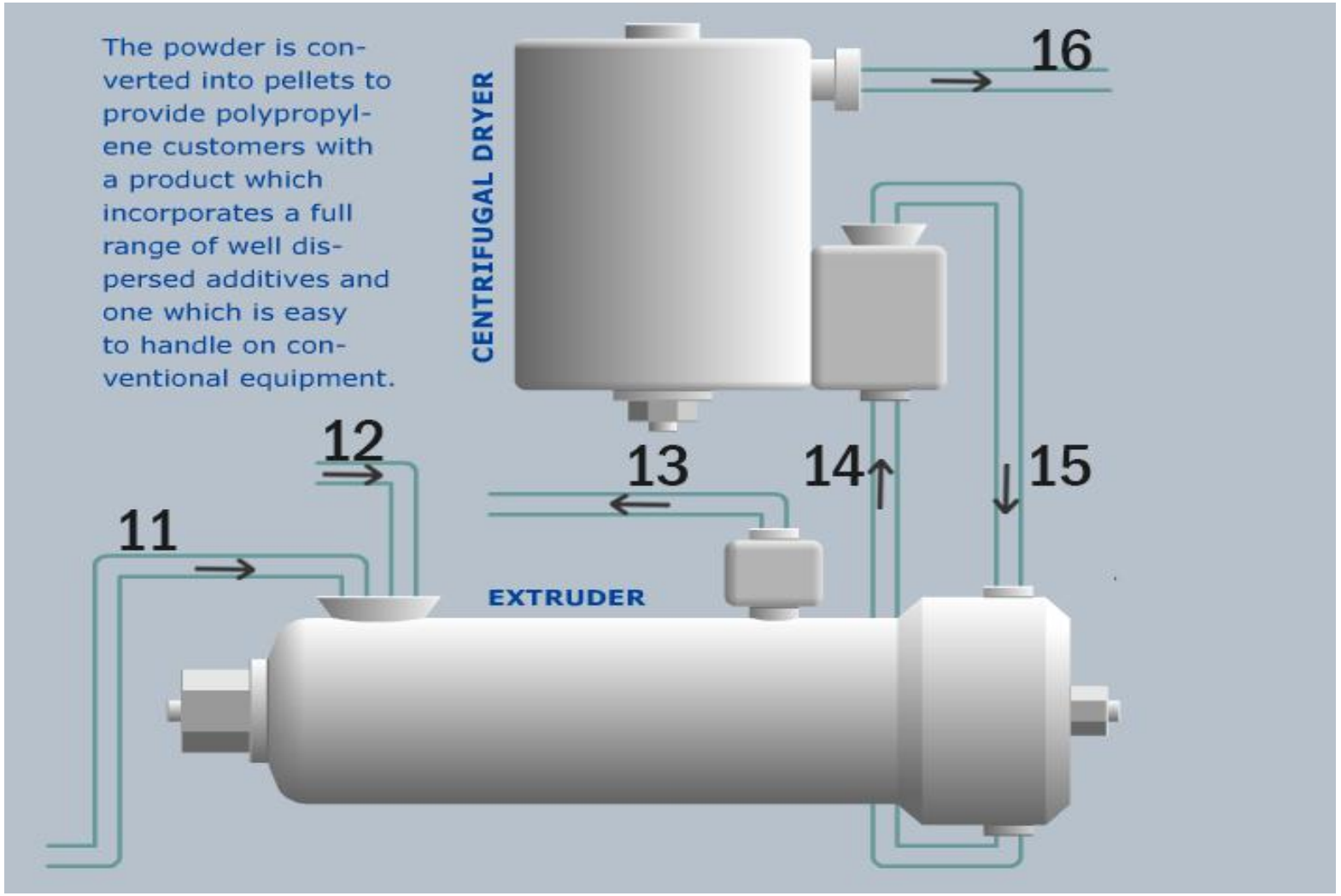
Degassing Vessel

Image Courtesy : GN Solids Control

Purge Column

Image Courtesy : jenike.com

EXTRUSION AND DRYING



Extrusion and Drying Unit

Extruder

Centrifugal Dryer

Recycle of Polypropylene

Why Recycle?

Environmental Impact of PP

Burning of plastics leads to environmental pollution.

PP products degrade very slowly – 20-30 years in landfills.

Additives – stabilizers & colorants contain a wide range of toxins including lead and cadmium.

Benefits of Recycling PP

Reduction in consumption of raw, finite resources.

~8% of all the oil produced worldwide is used for plastic production.

Relative to production from oil and gas, recycled plastic uses ~88% less energy.

Average Reclaimer Yield Values

Average Reclaimer Yield Values	
Bottle Type	**Base Resin Yield (%)**
Two-piece PET soda bottles (w/base cup) One-piece	65-75 (PET)
PET soda bottles and custom PET bottles	75-85 (PET)
Natural HDPE bottles (e.g., milk, water)	85-95 (HDPE)
Pigmented HDPE bottles (e.g., soap, detergent)	75-85 (HDPE)
PVC bottles	85-92 (PVC)
PP bottles	85-95 (PP)

PP Recycling Process

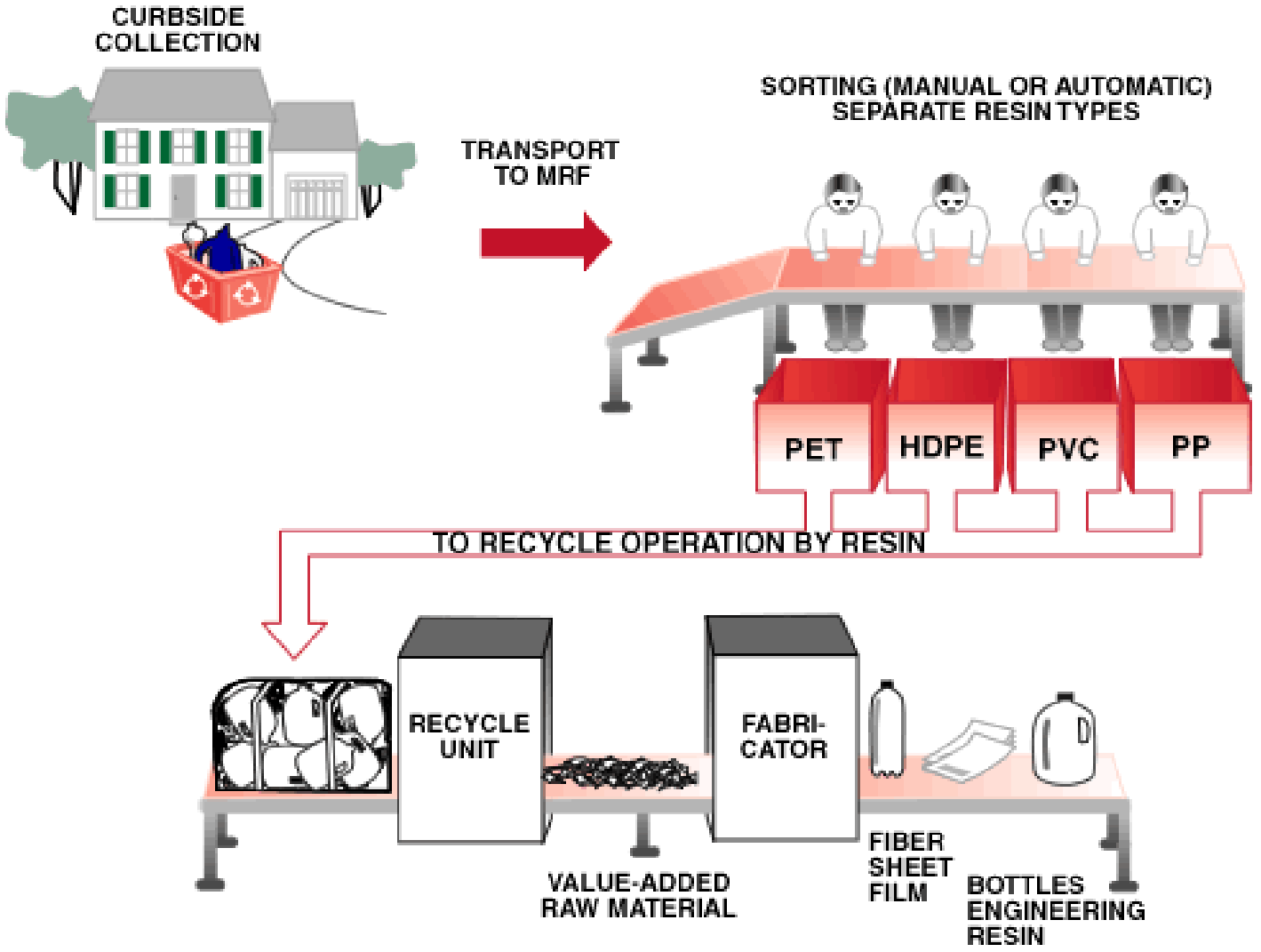
Collection

Sorting

Cleaning

Reprocessing by melting

Creation of new products


CURBSIDE
COLLECTION
TRANSPORT
TO MRF
SORTING (MANUAL OR AUTOMATIC)
SEPARATE RESIN TYPES
PET
HDPE
PVC
PP
TO RECYCLE OPERATION BY RESIN
RECYCLE
UNIT
FABRI-
CATOR
VALUE-ADDED
RAW MATERIAL
FIBER
SHEET
FILM
BOTTLES
ENGINEERING
RESIN

Collection

Involves accumulation of used plastic products from waste streams.

Usually contains a mixture of various plastic products.

Sorting

Separation of PP from other plastics.

Mostly by using the resin identification code.

In cases where the code is absent, separation is achieved using ‘sink-float’ technique.

Resin Identification Code

Polyethylene terephthalate

High Density PE

Polyvinyl chloride

Low Density PE

Polypropylene

Polystyrene

Polycarbonate

Cleaning

Paper labels and other attachments are removed.

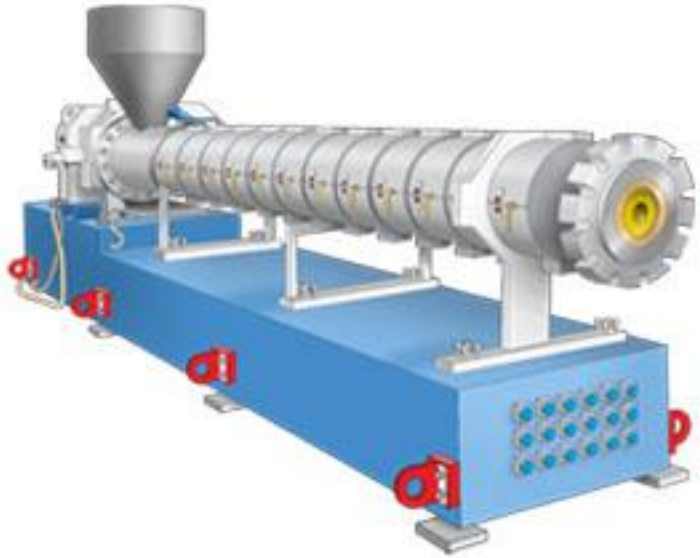
Products are granulated and washed giving rise to ‘clean flake’.

Flakes are converted to uniformly sized pellets to be fed into extruders and moulders.

Reprocessing by Melting

Pellets are fed into extruders.

Melted at 240^{o}C and cut into small granules.



Creation of new products

Key parameters of the recycled material like the melt flow index are measured to assess their suitability for use in various applications.

Most of the recycled plastic is then mixed with ‘virgin’ plastic (i.e. plastic that has not been produced via recycling) in a ratio of around 1:3 to produce new plastic products.

Challenges involved

PP is eventually affected by thermal degradation which compromises the structural integrity of the plastic.

Rule of thumb is that PP can be recycled four times in a ‘closed loop’ before the thermal degradation has negative impacts.

To decontaminate the recycled food grade PP for packaging.

Recycling facilities in India

Green-O-Tech India™

HIKON Industries

PlasticHQ

Alternative to Recycling – Fuel Production

Pulverized waste polymers are fed into the plant to give gas and liquid fuel.

Two stage pyrolysis process, converts all of the organic material at high temperature into useful fuels.

Almost no residue left for disposal.

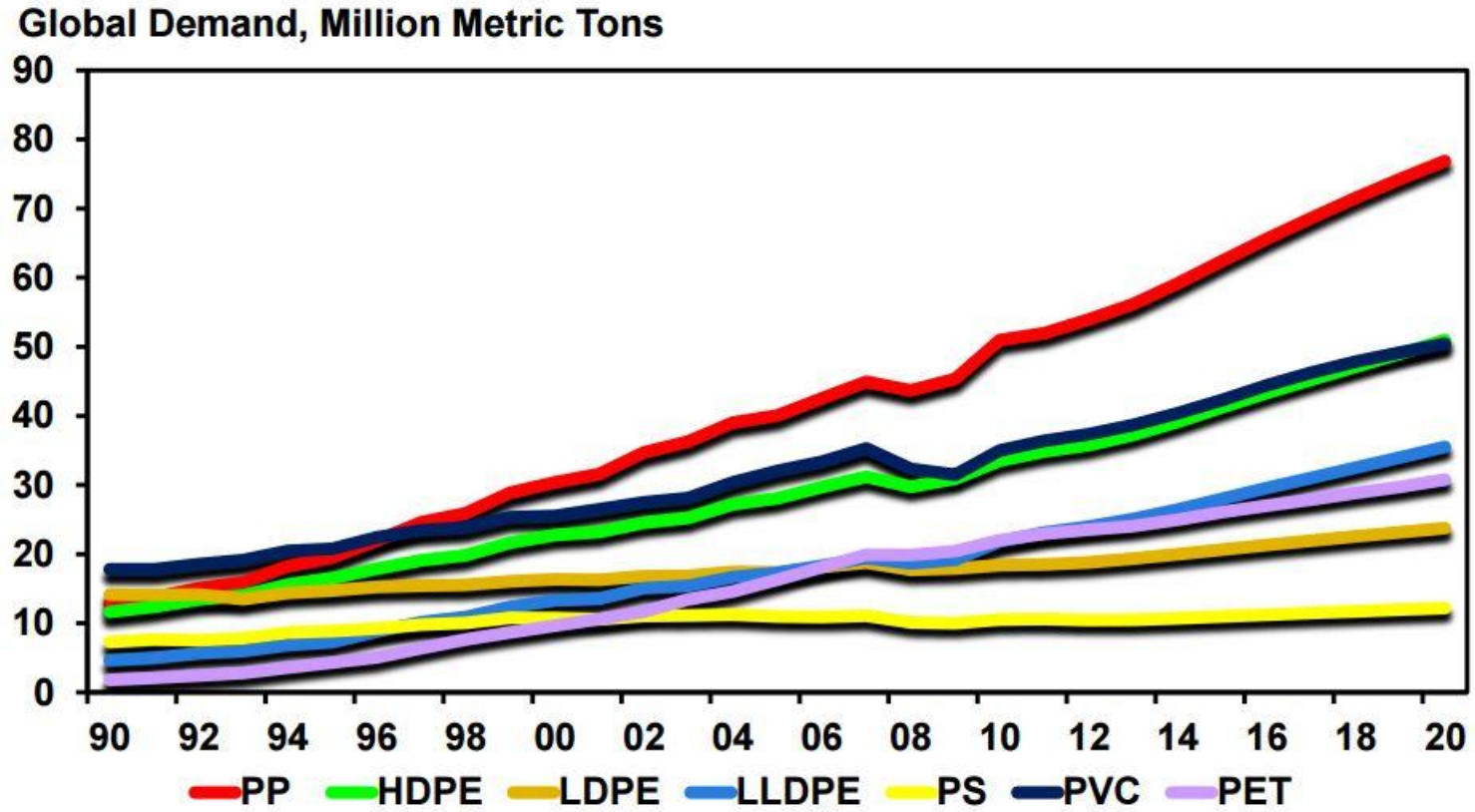
A pilot plant in CSIR-IIP, Dehra Dun can produce 300g per hour of fuel.

Future of Polypropylene

TRICON

ADDING A WORLD OF VALUE

PP DEMAND GROWTH



PP growth outpaced other polymers

Source - IHS

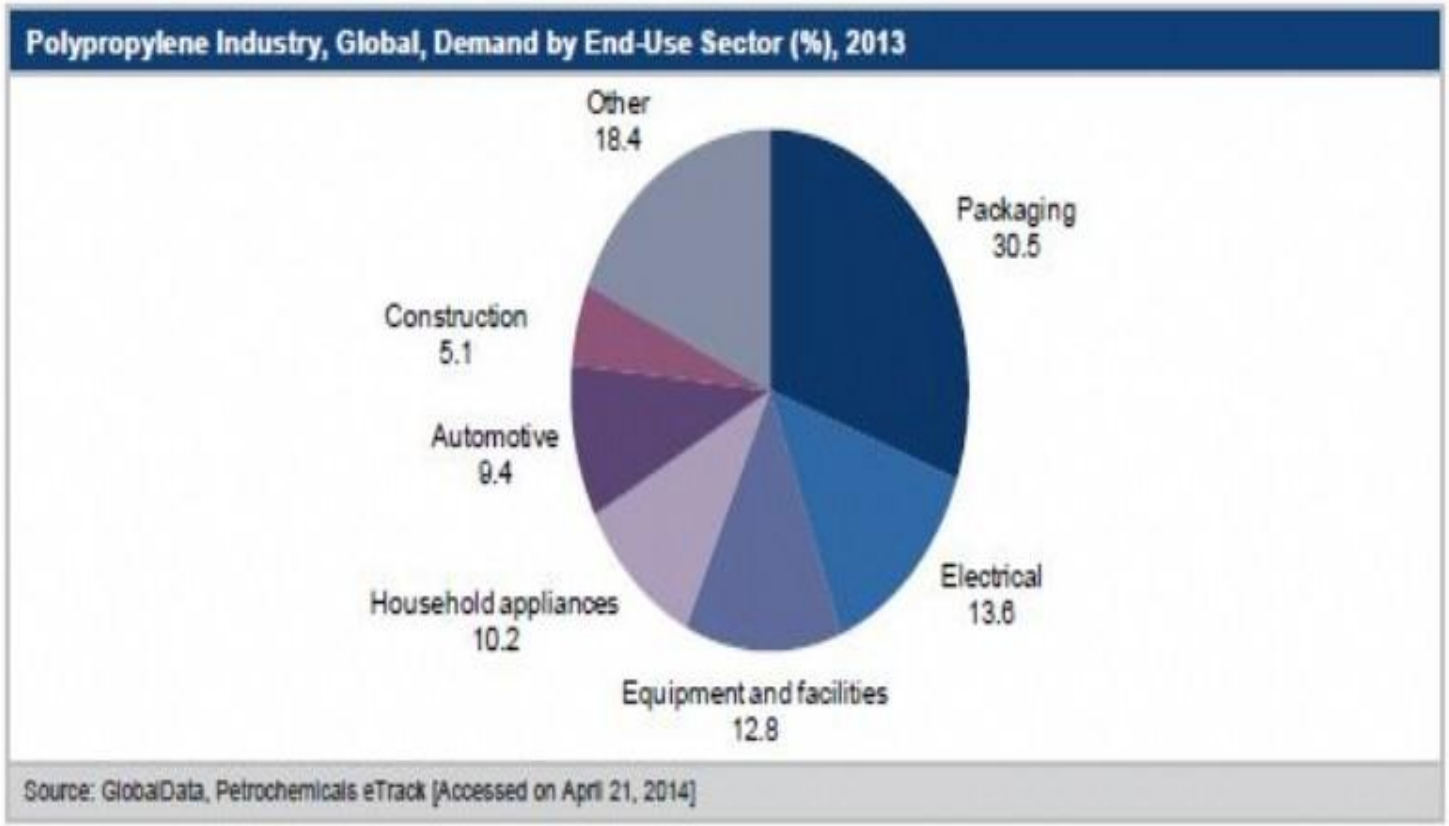
Key Attributes of Polypropylene

Polypropylene has the following key attributes which ensures that it will play an important role in the future of thermoplastics :-

1) Lightweight, tough and durable material
2) Efficient production processes that generate very little waste
3) Has a wide range of applications due to its versatile nature
4) Easily Recyclable
5) Highly Resistant to a wide range of chemicals
6) Its high melting range allows it to be used in microwavable containers and in medical devices that require high temperature sterilization

Table 1 Comparison of unmodified PP with other materials: Advantages [1]						
Property	**PP**	**LDPE**	**HDPE**	**HIPS**	**PVC**	**ABS**
Flexural modulus (GPa)	1.5	0.3	1.3	2.1	3.0	2.7
Tensile strength (MPa)	33	10	32	42	51	47
Specific density	0.905	0.92	0.96	1.08	1.4	1.05
Specific modulus (GPa)	1.66	0.33	1.35	1.94	2.14	2.57
HDT at 0.45 MPa. (°C)	105	50	75	85	70	98
Maximum continuous use temperature (°C)	100	50	55	50	50	70
Surface hardness	RR90	SD48	SD68	RM30	RR110	RR100
Cost (£/tonne)	660	730	660	875	905	1550
Modulus per unit cost (MPa/£)	2.27	0.41	1.97	2.4	3.31	1.74
ABS = acrylonitrile butadiene styrene *HIPS = high impact polystyrene* *RR = Rockwell R* *RM = Rockwell M* *SD = Shore Durometer*						

Major Market Sectors for polypropylene



Key Growth Markets for Polypropylene

1) Automotive Industry : Replacing metal parts of automotive vehicles with lightweight but strong polypropylene has shown to significantly improve fuel efficiency. Currently ~10 % of the total polypropylene is used in automotive industry. This number is expected to increase significantly in the future.

2) Packaging Industry : Another important application of polypropylene is in the replacement of glass in packaging. The density of glass is almost 2.5 times greater than that of polypropylene. Additionally, glass is prone to breakage unlike polypropylene. Already packaging accounts for 30 % of the total end product usage of polypropylene. It is expected to stay strong in the future.

Market Analysis - Global

• Global Polypropylene (PP) capacity was 64.2 MMT in 2011 against demand of 68.1 MMT

•The capacity is expected to increase to 77 MMT in 2016 with demand reaching 83 MMT

•Major Companies: ExxonMobil, Formosa, Borealis, Saudi Amarco, Westlake, Ineos, Chevron Phillips, Dow, Equistar, Oxychem, Formosa, Shell, Nova, Braskem, Williams, Borouge, and CPC Corp. – Taiwan

•PP price touched its lowest level in last ten years in Nov'08 – 725$/MT-SE Asia prices while in May'12 the prices touched 1385$ MT corresponding to Crude 107.31 $/Barrel and Naphtha 886 $/MT.

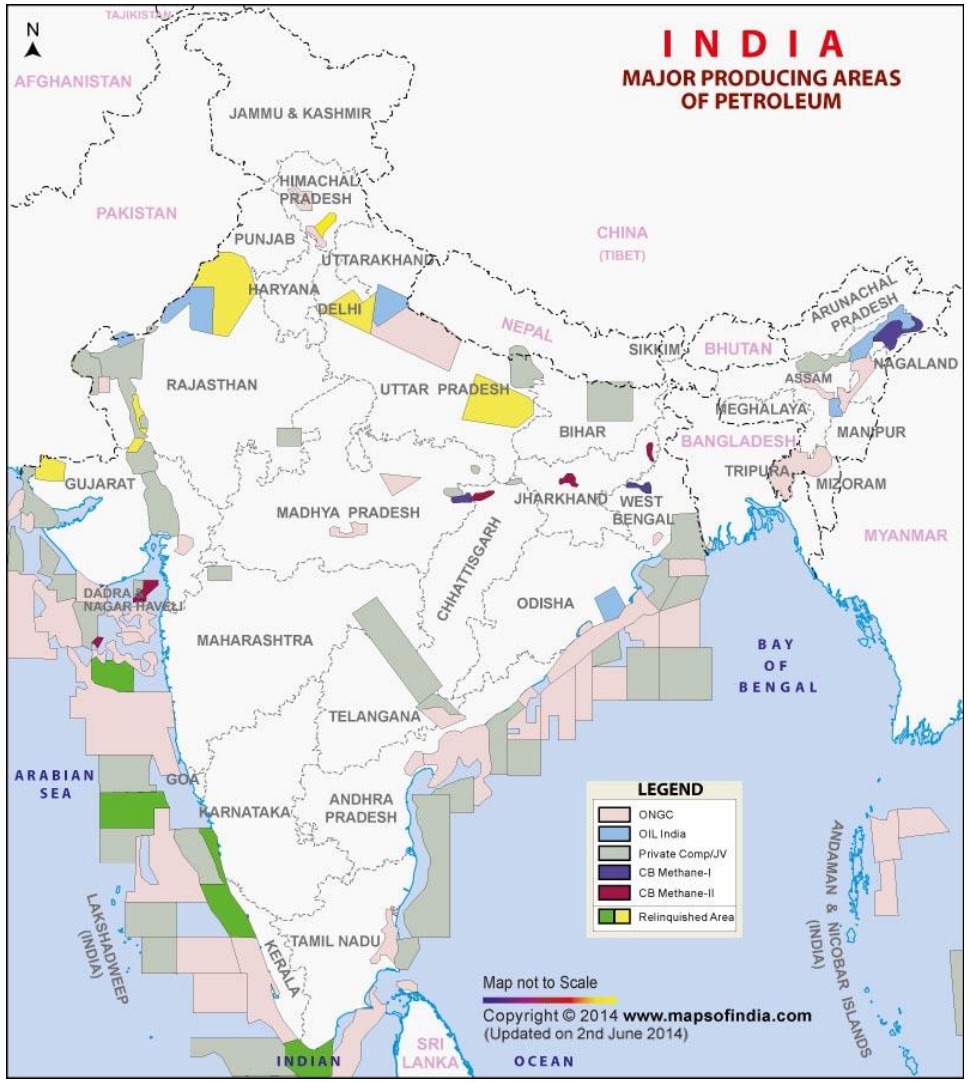
Market Analysis - India

- Total PP capacity is expected to reach 4715 KTA by 2016-17
- Reliance Industries Ltd has planned capacity expansion to 2885 KTA by 2016-17
- OC 650 KTA, HPCL 440 KTA, OPAL 340 KTA, HPL 340 KTA and BPCL Assam GC 60 KTA

Capacity (kt)	Actual	Projected				
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
RIL	2710	2725	2725	2725	2885	2885
HPL	340	340	340	340	340	340
IOC	650	650	650	650	650	650
OPAL		340	340	340	340	340
HPCL	440	440	440	440	440	440
BPCL			60	60	60	60
Total	**4140**	**4495**	**4555**	**4555**	**4715**	**4715**

Source: CPMA

Location Preference- India



Major Criteria:

- Availability of Propylene monomer
- Water
- Proximity to ports for export
- Proximity to Industrial markets
- Availability of road and rail network

Major Producers

1. Reliance
2. Haldia Petrochemicals
3. Gas Authority of India Limited
4. GE Plastics India
5. IPCL
6. NOCIL
7. Karnataka Petrosynthese Limited
8. Supreme Industries

Growth Scenario

- Since polypropylene has made an impact into every aspect of life and work, India also is not far from being affected. The polymer has found its way into various industrial applications and has become an integral part of the economy as a whole. India has an installed polymer production capacity of around 4500 thousand metric tons per year. Polyethylene and polypropylene production accounts for around 70% of the total polymer production in India.
- The major producers of polypropylene in India are Reliance, Haldia Petrochemicals and Gas Authority of India. Regarding the consumption of polymers in the country, India stands at the 8th place with a mere 4 kg per capita consumption per year. The Indian plastic polymer consumption in 2003-04 stood at around 4.2 million tons. But, it is expected to take a jump from the eighth position to the third position in the major consuming countries' list in the upcoming years if the rate of consumption continues.

- The polymer industry in India is growing @ 12-15% annually. India was a net importer of plastic products some time ago but due to the high rate of development in this sector in the country, India has transformed into a net exporter. The country registered an export surplus of Rs 462 crore in plastic products in the year 2003, though 1995-96, India was importing plastic polymers worth a staggering Rs 1538 crore. The prices of polypropylene in the country are excessively fluctuating as they directly depend on the international demand and supply conditions.

- Polypropylene is traded in the Indian commodity exchange namely **Multi Commodity Exchange of India**.

SAFETY

Polypropylene is considered the best one on all plastic from the side of safety. this is the stronger plastic that is heat resistance because of its high heat tolerance.

Polypropylene is not likely to leach even when uncovered to hot water or warm. This plastic is approved for use with food and beverage storage.

Polypropylene plastics able to reused safely and with hot beverages. Also, it resins are not likely to be toxic to the environment. Polypropylene is not considered biodegradable as it biodegrades at a slow rate.

When you are handling or processing of polypropylene resins, exposure to hot material, fumes and dust may take place. For such activities exposure should be controlled by choosing and applying the appropriate risk management measures.

IMAGE COURTESY

1) CSTR : enviropro.co.uk
2) Cyclone : AIREX Industries
3) Degasser Vessel : GN solids control
4) Purge Column : jenike.com
5) Extrusion and Drying : New Holland

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1. http://www.crnindia.com/commodity/pp.html
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3. CPMA

Thank You