Sundyne®

Pumps & Compressors for Advanced Plastic Recycling Processes

Sundyne Pumps | Sundyne Compressors | ANSIMAG Sealless Pumps | HMD Kontro Sealless Pumps | Marelli Bombas | PPI Diaphragm Compressors | SUNFLO®

What is Advanced Recycling?

Advanced Recycling is a set of processes that use thermochemical reactions to break plastics down into liquid or gas molecules, or monomers, which can then be used as a feedstock for new products.

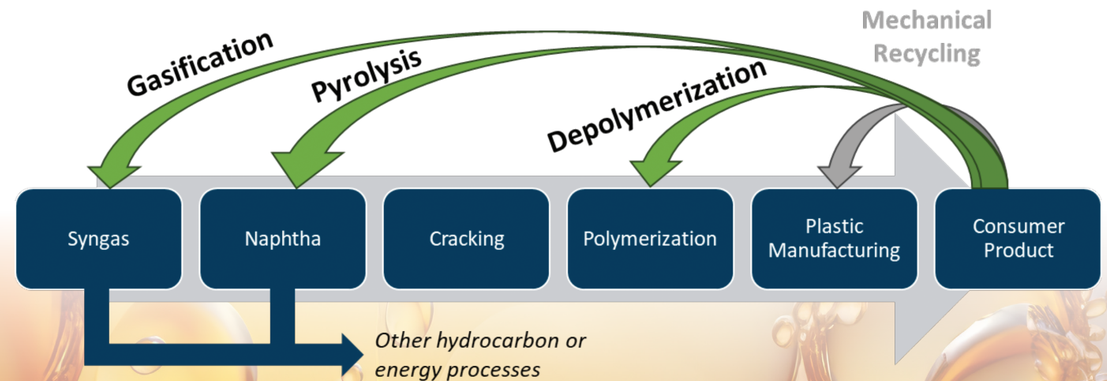
Advanced recycling is important because it promotes a circular economy in two key ways:

1. **Expanded scope of waste that can be recycled:** Advanced recycling expands the types of plastics that can be recovered, when compared to traditional *mechanical* recycling.
2. **Improved quality of recovered products:** Advanced recycling recovers the molecular building blocks of waste plastic. These raw materials can then be used as a feedstock for new products – including virgin plastics or hydrocarbon fuels of the same quality and composition as the original product.

There are three main categories of advanced recycling processes:

1. **Gasification:** Break-down plastic under high temperatures (ranging from 500 to 1,300°C) in the presence of oxygen and/or steam to produce ***syngas***.
2. **Pyrolysis:** Break-down plastic under high temperatures (ranging from 300 to 900°C) with little or no oxygen present to produce ***pyrolysis oil***.
3. **Depolymerization (or Chemolysis):** Chemical treatment to convert plastics, typically polyethylene terephthalate (PET) waste, into ***monomers*** using a solvent.

The choice of technology is driven by the composition of the plastic waste feedstock and the desired end-product.

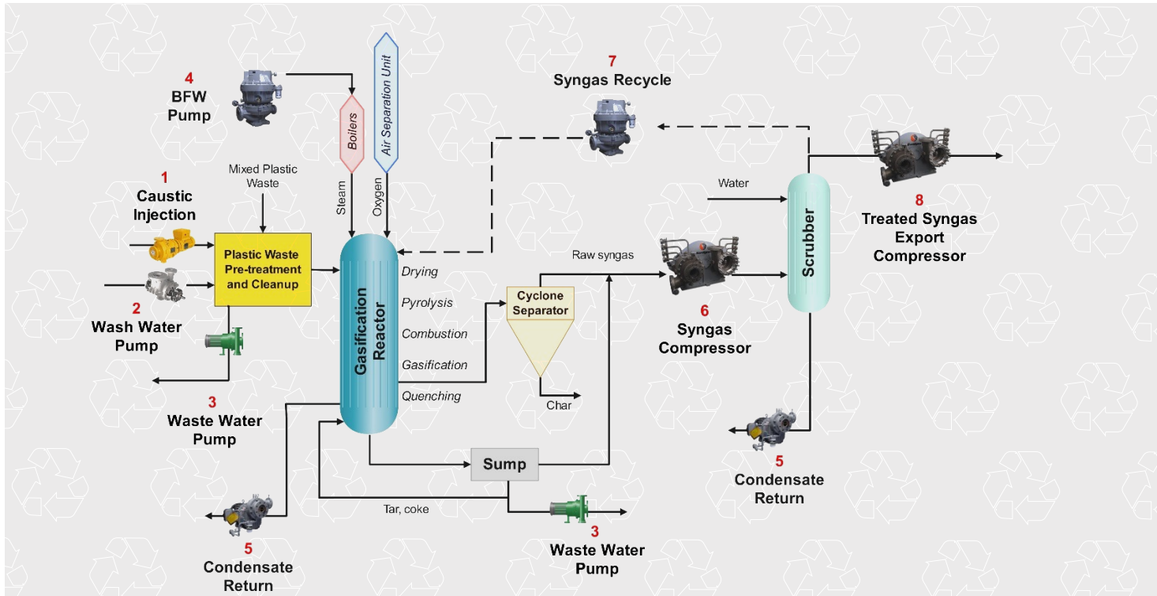


Gasification

Gasification is a thermochemical process that breaks-down a fossil fuel-based material into syngas, which is a mixture of CO and H_2. Gasification can also use *biomass* or *municipal solid waste* as the feedstock. The recovered syngas can be upgraded and used as a feedstock for new plastics or fuels, but is more commonly valued in electricity or heating directly.

The typical process steps include:

1. **Feedstock preparation:** Reduce moisture content of feedstock and generate steam.
2. **Pyrolysis:** Thermal degradation in the absence of oxygen to break down the plastic into volatile gases and hydrocarbon residues.
3. **Combustion:** A controlled amount of oxygen is added to burn the volatile gases to produce CO and steam, while releasing heat which is used throughout the process. The steam then reacts with the hydrocarbon residues (e.g. coke, char, tar) to produce H_2 and additional CO. This step occurs in the same reactor as the pyrolysis step, but in a different zone.
4. **Reforming:** Depending on the syngas composition, steam methane reforming can be used to raise the hydrogen content of the syngas and convert any residual methane.



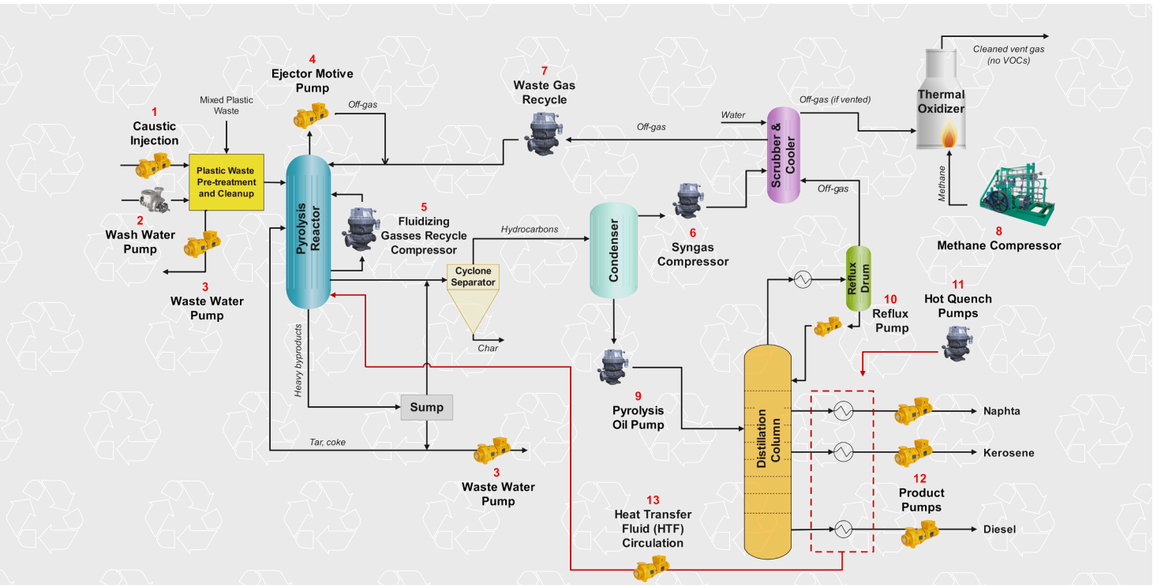
Location	Service	Equipment Type	Medium
1	Caustic Injection	HMD, Ansimag	KOH or other caustic for de-chlorination
2	Wash Water	Sunflo	Water
3	Waste Water	HMD, Ansimag	Contaminated water
4	BFW Pump	Sundyne LMV, Sunflo	Boiler feed water
5	Condensate Return	Sunflo	Water
6	Syngas Compressor	Sundyne LMC, BMC, LF-2000	Syngas ($CO + H_2$)
7	Syngas Recycle	Sundyne LMC, BMC, LF-2000	Syngas ($CO + H_2$)
8	Treated Syngas Export	Sundyne LMC, BMC, LF-2000	Syngas ($CO + H_2$)

Pyrolysis

Pyroslysis is similar to gasification, except that the plastics are heated in a sealed pyrolysis reactor in the absence of oxygen. This prevents combustion but breaks the long polymer chains into smaller hydrocarbons via thermal decomposition. The process mainly produces liquid pyrolysis oils. Any gaseous byproducts can be condensed to produce liquid oil or sent for further processing, and solid char or carbon black residues can be recovered for other uses.

The typical process steps include:

1. **Feedstock preparation:** Reduce moisture content of feedstock and generate steam.
2. **Pyrolysis:** Thermal degradation in the absence of oxygen to recover pyrolysis oil, CO_2, H_2, CO and other light hydrocarbons.
3. **Separation:** The hot gases and liquids are condensed and then separated via a distillation column to produce hydrocarbon product streams for downstream use.



Location	Service	Equipment Type	Medium
1	Caustic Injection	HMD, Ansimag	KOH or other caustic for de-chlorination
2	Wash Water	Sunflo, Sundyne LMV	Water
3	Waste Water	HMD, Ansimag	Contaminated water
4	Ejector Motive Pump	HMD, Ansimag	Condensate water or other motive fluid
5	Fluidizing Gases Recycle	Sundyne LMC, BMC, LF-2000	H_2, CO, CO_2, N_2, CH_4
6	Syngas Compressor	Sundyne LMC, BMC, LF-2000	Syngas (CO + H_2)
7	Waste Gas Recycle	Sundyne LMC, BMC, LF-2000	H_2, CO, CO_2, N_2, CH_4
8	Methane Export	PPI, Sundyne LMC, BMC, LF-2000	Methane
9	Pyrolysis Oil Pump	HMD, Sundyne LMV, Marelli	Pyrolysis Oil
10	Reflux Pump	HMD, Sundyne LMV, Marelli	Hydrocarbon
11	Hot Quench Pumps	Sundyne LMV, Marelli	Water
12	Product Pumps	HMD, Sundyne LMV, Marelli	Naphtha, Kerosene, Diesel, hydrocarbons
13	Heat Transfer Fluid Circulation	HMD	Heat Transfer Fluid

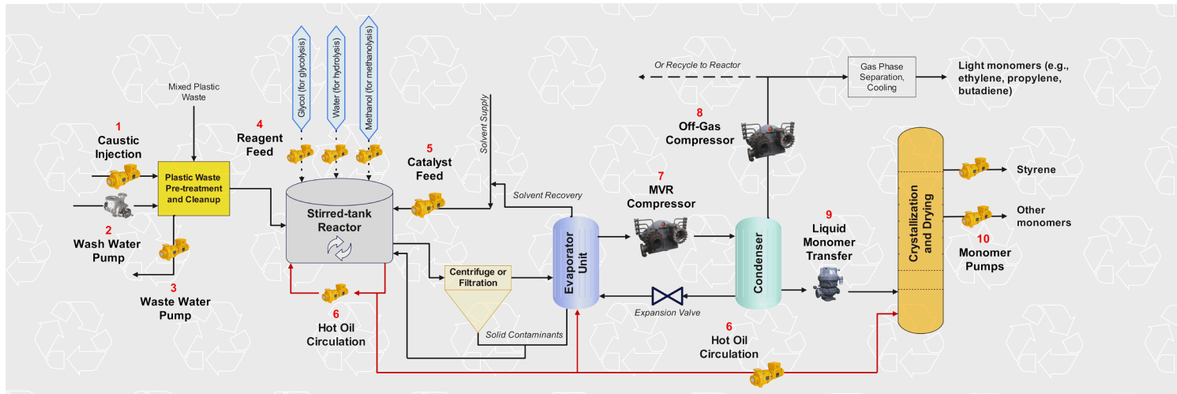
Depolymerization

Depolymerization, also called chemolysis, is an advanced recycling process that uses thermal and chemical reactions to break-down plastic *polymers* into their original monomers. By recovering the monomers, instead of a syngas or liquid fuel, depolymerization is used for plastic-to-plastic recycling. There are several different methods of depolymerization, each using a distinct medium as a reagent to promote the decomposition reaction. The most common methods are:

- **Hydrolysis:** Using water to break down polyethylene terephthalate (PET) into terephthalic acid (TPA) and ethylene glycol (EG).
- **Methanolysis:** Using methanol to break down PET into dimethyl terephthalate (DMT) and EG.
- **Glycolysis:** Using ethylene glycol to break down PET into bis(2-Hydroxyethyl) terephthalate (BHET).

In general, the typical process steps include:

1. **Feedstock preparation:** Reduce moisture content of feedstock and generate steam.
2. **Thermochemical Decomposition:** Through the addition of heat, catalysts, and chemical reagents, break-down the plastic polymers into monomers.
3. **Separation:** The recovered monomers and intermediates are condensed and then separated via a distillation column to separate the individual building blocks, such as ethylene glycol (EG), dimethyl terephthalate (DMT), or styrene. At this point, these product streams can be repolymerized into new plastics.

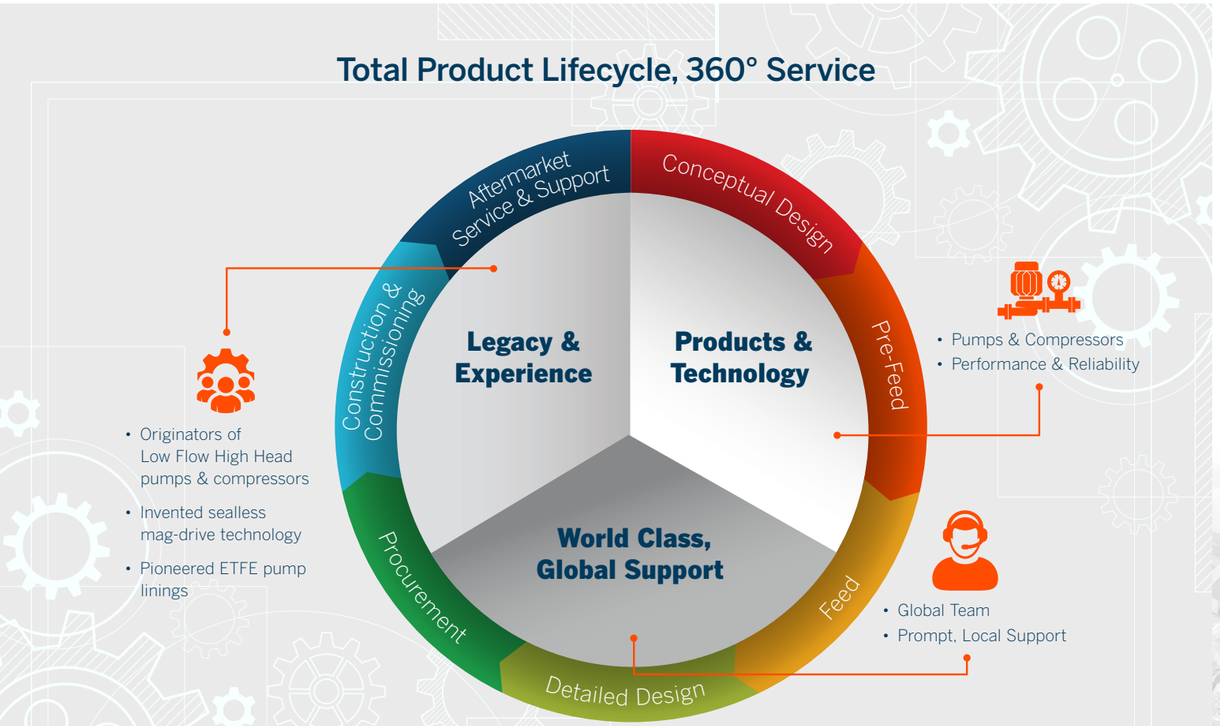


Location	Service	Equipment Type	Medium
1	Caustic Injection	HMD, Ansimag	KOH or other caustic for de-chlorination
2	Wash Water	Sunflo, Sundyne LMV	Water
3	Waste Water	HMD, Ansimag	Contaminated water
4	Reagent Feed	HMD, Ansimag, Sunflo	Glycol for glycolysis, water for hydrolysis, methanol for methanolysis (depends on reaction)
5	Catalyst Feed	HMD, Ansimag	Catalyst (acid, base, enzyme – used mainly for hydrolysis)
6	Hot Oil Circulation	HMD, Ansimag	Heat transfer fluid
7	MVR Compressor	Sundyne LMC, BMC, LF-2000	Gaseous monomers
8	Off-gas compressor	Sundyne LMC, BMC, LF-2000	Gaseous monomers, e.g. ethylene or light olefin
9	Liquid Monomer Transfer	HMD Sealless, Sundyne LMV, Marelli	Crude liquid monomer stream
10	Monomer product pumps	HMD Sealless, Sundyne LMV, Marelli	Distilled monomers, typically medium or heavy-weight such as styrene

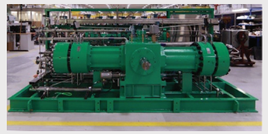
Sundyne's Value Proposition for Advanced Recycling

Sundyne's unique combination of technology, expertise, and support provides full life-cycle support for advanced recycling applications. Sundyne support covers initial design in pre-FEED all the way through to 24x7 support on operating machines. Sundyne utilizes a global network of Aftermarket Specialists and Authorized Service Centers to ensure highest level of customer support on machines.

Total Product Lifecycle, 360° Service



PPI Compressors



Experience unmatched reliability and leak-free operation with Sundyne's PPI diaphragm compressors, engineered to provide ultra-pure compression for hydrocarbon products and critical gases. Ideal for applications requiring small flow rates and high pressures, diaphragm compressor technology stands alone in delivering superior performance where other volumetric compressors fall short. The sealed design ensures exceptional safety and minimal maintenance, with no lubrication required on the gas side, making it an optimal choice for demanding industrial environments.

Sundyne Compressors

Developed from more than 70 years of technological advancement and with 5,000 units installed worldwide, Sundyne's latest generation of integrally geared compressors delivers the industry's best engineered-for-reliability solution for the Energy, Petrochemical, Chemical and General Industry sectors. Designed to meet API-617 and related standards for mission-critical applications, our solution ensures up to 7 years of continuous operation – minimizing downtime, maximizing performance and delivering oil-free process gas with zero emissions.

Sundyne LMV Pumps

Sundyne integrally geared centrifugal pumps are optimized for low flow-high head applications. They offer the highest efficiency in the low flow range with a proven track record of high reliability. A single impeller in a Sundyne LMV pump spins at high speed to produce the same head as a multistage pump running at synchronous speed. Sundyne LMV pumps are ideally suited for services such as boiler feed water pumps, condensate transfer pumps, solvent circulation pumps and reflux pumps. To achieve even higher heads, two or more integrally geared stages run in series in a Sundyne HMP pump. The compact design reduces installation costs, and the simplicity limits the number of spare parts while making maintenance easier.

Sealless Magnetic Drive Pumps – HMD and ANSIMAG

Sundyne sealless pumps provide optimum safety and environmental protection for a wide range of applications found within Advanced Plastic Recycling. These magnetic driven pumps are designed for harsh and hazardous liquids, and applications that are difficult to seal. HMD Kontro metallic and Ansimag ETFE-lined sealless pumps ensure total product containment, increase reliability and uptime and simplify maintenance with no seals or seal support systems, whilst meeting industry standards such as ASME, ISO and API.

Marelli Pumps

Marelli pumps leverage a track record of more than 60 years in centrifugal pump design, development, manufacturing and service, to fulfill the latest standards for oil & gas, petrochemical and clean energy markets. Marelli pumps are designed for extreme reliability and a wide range of flow rates, to accommodate the most stringent customer specifications.

Sunflo Pumps

Industrial grade Sunflo pumps are specifically designed for low flow-high head applications such as boiler feed water, condensate, demineralized water circulation. Sunflo pumps leverage the engineering knowledge and legacy of the Sundyne heavy duty API integrally geared pumps. A single impeller runs at high speed to produce high heads in a very compact and reliable design. The close coupled configuration eliminates alignment issues, simplifies installation and further reduces footprint. The Sunflo cartridge shaft assembly comes complete with all the rotating parts and enables quick and easy servicing of the pump in-place.

When it comes to Advanced Recycling applications, Sundyne is the **Safer, Better, Best** choice.

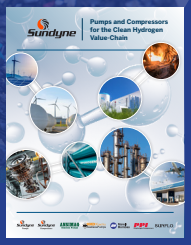
Safer for Operations

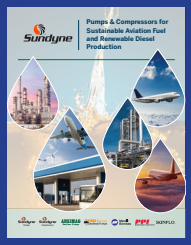
Better for the Environment

Best Total Lifecycle Value

For more information on Sundyne's product fit in Clean Energy Markets, refer to our other clean energy brochures:

- Carbon Capture and Storage
- Clean Hydrogen Value Chain
- Sustainable Aviation Fuel and Renewable Diesel





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