

CERTH / CPERI, Greece

The Chemical Process and Energy Research Institute (CPERI) at CERTH (Centre for Research & Technology, Hellas) is a non-profit research and technological development organization situated in Northern Greece. The development strategy of CPERI has been based on establishing strategic collaborations with leading international industrial corporations, developing strong links with research centres and universities within the European Research Area (ERA) and contributing to the training of young scientists and engineers in the latest technologies.

Throughout its lifetime CPERI has acquired excellent analytical instrumentation and developed state-of-the-art experimental units and setups, valued at several million Euros.

CPERI's mission is to conduct high calibre basic and applied research, to develop novel technologies and products and to pursue scientific and technological excellence in selected advanced areas of Chemical Engineering, including energy, environment, materials and process technologies, in response to the needs of the Greek and European industrial and productive sector.

CPERI has developed excellent experimental facilities and acquired high quality analytical instrumentation, including among others:

- Pilot plant units and laboratory scale units for the evaluation of refinery and petrochemical catalysts;

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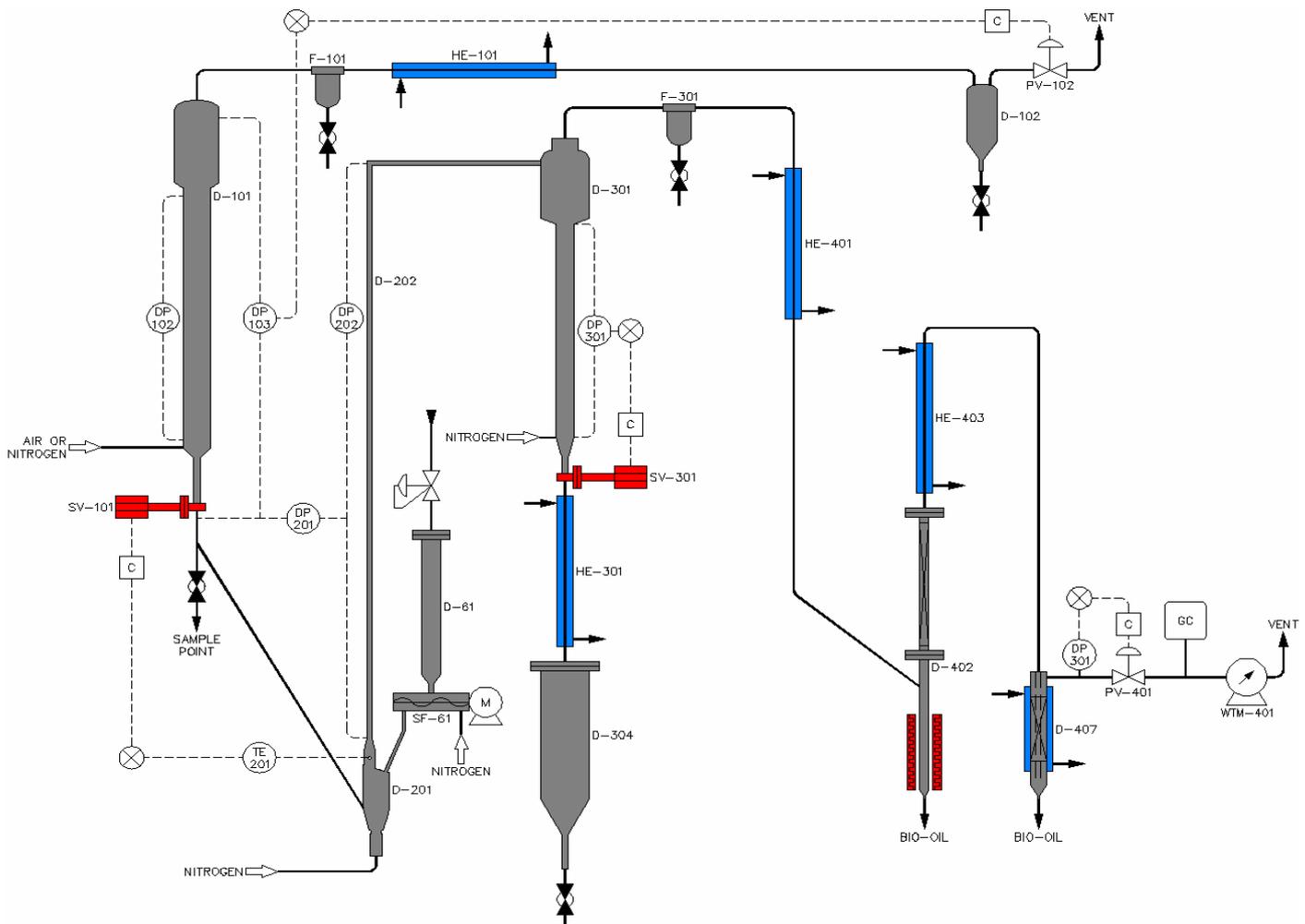


Figure 1: Schematic diagram of a process development unit for biomass pyrolysis.

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Figure 2: FCC pilot plant unit in CPERI.

- Modern laboratory equipment for the detailed physical, chemical and morphological characterization of inorganic materials, catalysts, polymers, membranes and molecular sieves;
- Morphology, nanoparticles size measurement, structural properties, crystalline phase characterization, identification of chemically different species at magnifications up to 1.200.000 with High Resolution Transmission Electron Microscopy (HRTEM) equipped with X-ray EDS.

Pilot plant units available through BRISK

1. Pilot scale catalytic biomass pyrolysis unit

A retort unit for upgrading of biomass for biofuels and production of organic chemicals is included in CPERI facilities. The pilot plant unit (Figure 1), constructed in CPERI, comprises of a catalyst regenerator, a feed-vibrating hopper, a fluidization reactor (that consists of an injector and a riser

reactor), a product stripper along with a hot cyclone and a filter housing, and finally a product condensation/recovery section. The pilot plant is fully automated based on a special industrial computer control system. The unit can process up to 20 gr/min of biomass (50-800 μ m) and can circulate up to 300 gr/min of catalyst or inert material. Reactor temperatures ranging from 450-750 $^{\circ}$ C can be used.

2. Pilot plant FCC unit

A riser based continuous pilot plant unit for catalytic cracking is also available at CPERI's facilities. A photo of CPERI's FCC pilot plant unit is shown in Figure 2. The FCC pilot plant operates in full circulating mode with continuous regeneration.

It consists of a vertical reactor (riser), a fluid bed regenerator, the stripper and the lift line. The reactions take place in the riser and the separation (stripping) of gases from the solid catalyst occurs in the stripper vessel. The solids flow through a second slide valve and through the spent catalyst lift line return to the reactor bottom following regeneration. The fluid bed regenerator reactor is used to burn the carbon that covers the catalyst surface as a by-product of the cracking process.

The fluidization gas (air) is introduced from the base of the regenerator and its flow rate is controlled by a mass flow controller. The spent catalyst enters the top of the fluid bed counter current to the air flow. The regenerator exit stream passes through cyclones that remove any entrained solids. The remaining products are cooled by a heat exchanger and subsequently their total flow is measured by a wet test meter and analyzed by a GC. Flue gases concentrations were also measured on-line using an analyzer (Horriba, PG-250), which can measure the following flue gases: O₂, CO₂, CO, NO, NO_x, SO₂. The gas sample to this analyzer comes directly from the regenerator exit.

3. Pilot plant HDS unit

The existing hydrodesulfurization (HDS) pilot plant unit in CPERI (Figure 3) was originally designed for HDS of petroleum fractions, while today it is used for the study of the wax hydrocracking

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process. Thus, a major revamp was performed in order to run unattended with wax feeds. The unit modifications were planned and designed in cooperation with an engineering company and included a new pump suitable for wax viscosities, heat tracing of the pump and pipes, modifications to separation system, auxiliary feed system available for emergency plugging operation and a new pumping station for premixing of wax with diluent or sulfiding agent (for catalyst activation).

The unit reactor is of fixed bed type capable of working at temperatures up to 550°C and pressures up to 150 atm. The hydrogen is introduced in the reactor through an appropriate feed system while the wax feed through a pump. The reactor outlet is cooled by a double pipe cooler and is led to a separator where the gas and liquid parts were separated. Both liquid and gas streams are completely analyzed in CPERI's analytical facilities. The pilot plant unit having a full system of alarms and protections (detectors) is fully automated and functions by means of a computer connected with an automatic control system.

4. Bench-scale high pressure test unit

The high pressure small scale test unit of CERTH/CPERI, is a newly constructed versatile unit for the evaluation of the activity and selectivity of solid catalytic materials in different high pressure reactions. The unit is equipped with a feed inflow system able to supply both gases and liquid feeds. There are three gas lines, controlled by high accuracy mass flow controllers and one liquid feed line, delivering liquid hydrocarbon feedstocks via a high precision pump.

The unit operates with a stainless steel fixed bed reactor, externally heated with a three-zone furnace, while the exit stream of the reactor is cooled via a heat exchanger and is directed to a system of vessels for the separation and collection of the liquid and gaseous products. The reaction temperature is monitored with a thermocouple inserted in the catalytic bed. Both the liquid products and the gaseous stream are analyzed with gas chromatographs. The test facility can operate to temperatures up to 600°C and pressures up to 100 atm.

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Figure 3: HDS pilot plant unit at CPERI



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