

Test plant for gas/liquid reactions – e. g. for process intensification in chemical production.

Scope of plant

The test plant allows for the investigation of reactions in the gas/liquid phase, which are often applied in the chemical and pharmaceutical industries. Based on a stirred reaction vessel, the development of gas applications on a technical scale is made possible. Applicable reaction gases are oxygen – especially for oxygen-enriched operation – hydrogen, carbon monoxide and carbon dioxide.

Plant description

The following components are part of the test plant:

- Stirred reactor with external circuit
- Impeller mixer with high gas/liquid mass transfer rate
- Temperature control
- Storage vessel with feed pumps
- Vessel for product removal
- Gas metering for two reaction gases, e. g. oxygen and nitrogen
- Pressure adjustment and inerting with nitrogen
- Oxygen analyser (on-line; incl. sample gas preparation) for feed gas and off-gas analysis

The test plant is controlled by a process control system and can be operated in the batch, semi-batch and continuous mode. The stirred reactor and heat exchangers can be heated and cooled.

Fields of application

With the test plant, the following reactions can be examined:

- Air oxidations in the oxygen-enriched mode
- Reductions such as hydrogenations (e. g. for catalyst testing)
- Reactions with carbon monoxide or carbon dioxide

The influence of temperature, residence time, gas pressure (partial pressure), gas distribution and mass transfer on the turnover and selectivity of the reaction can be determined by experiments. Based on the results gained, the kinetic description can be evaluated for subsequent modelling and scale-up measures. In addition, applicable pressure and temperature conditions allow for low temperature reactions ($> -80^{\circ}\text{C}$) and also for operations with supercritical carbon dioxide (sc-CO_2).



Test plant with stirred reactor

Experiments and experiences

Oxidations

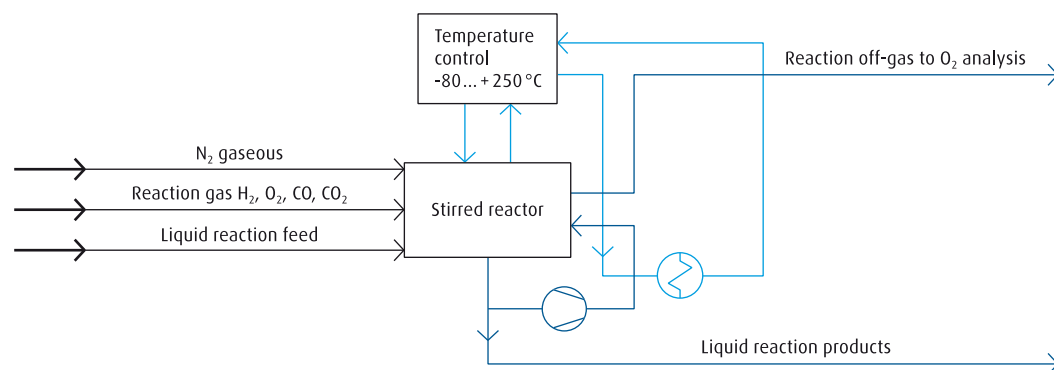
The test plant has already been used for the investigation of the efficiency of oxygen enrichment with respect to various air oxidations applied on a technical scale when oxidising:

- Cumene → Cumene hydroperoxide (phenol/acetone production)
- Toluene → Benzoic acid
- para-Xylene → Dimethylterephthalate (DMT)

Reductions

Hydrogenations in the liquid phase applying a catalyst suspension have been examined, e. g. the production of 1,2-propanediol from glycerol.

Basic flow diagram



Technical data

Stirred reactor

Maximum pressure	100 bar
Temperature	-80 to +250 °C
Volume (total)	15 litres
Volume (effective)	10 litres
Fittings	Gassing ring, gassing lance, cooling/heating coil, filling level measurement, temperature measurement, impeller shaft for various impeller arrangements, inerting of head space

Pumps

Feed pump	
Max. pressure increase	100 bar
Flow rate	5-50l/h
Circuit pump	
Flow rate	5-50l/h

Services and know-how

The test plant is located and operated on Linde's premises in the south of Munich (Pullach/Germany).

The services offered encompass all capabilities necessary for the industrial realisation of the gas application:

- Plant operation
- Laboratories for gas and liquid analysis
- Evaluation of kinetics
- Scale-up calculations for the simulation of the technical-scale installation

Linde's long-time experience and the available hardware, e. g. apparatus for oxygen supply and injection in case of oxygen enrichment, can contribute substantially to the subsequent implementation of the gas application on a technical scale.

Linde's expertise in gases and procedural issues is the basis for an individual and straightforward project handling. Efficient and approved process simulation programs and proprietary databases ensure optimum design, safe plant operation and economic use of technical gases.

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