SIEMENS

Gas Analysis in PTA (Phthalic anhydride) production plants

Application Note Process Analytics

Phthalic Anhydride

Phthalic anhydride (PTA, $C_8H_4O_3$), an anhydride of dicarboxylic acid, has been produced first in 1872 by oxidation of naphtalene. It has been used commercially since that time and is comparable in its importance to acetic acid. The most important derivates of PTA are plasticizers, polyester resins and dyes.
Production process of PTA has been improved several times, a breakthrough that led to high quality production was the development of the gas-phase oxidation of naphtalene or o-xylene in an air stream using different types of catalysts.

Production of PTA

Raw material for PTA was first only coal-tar naphtalene and thus depended strongly on the production of coke, which could not follow the increasing demand for naphtalene. Since 1960 a shift took place therefore in raw material base from naphtalene to o-xylene, which is available in adequate quantities from cracking plants and refineries. Nowadays new plants sometimes are capable of processing naphtalene and o-xylene or mixtures of the two.

Production processes and plants differ in details depending on the manufacturer and plant engineering.The oxidation of o-xylene is performed at a temperature of 360-390 °C according to $C_6H_4(CH_3)_2 + 3O_2 = C_8H_4O_3 + 3H_2O$ using a catalyst.

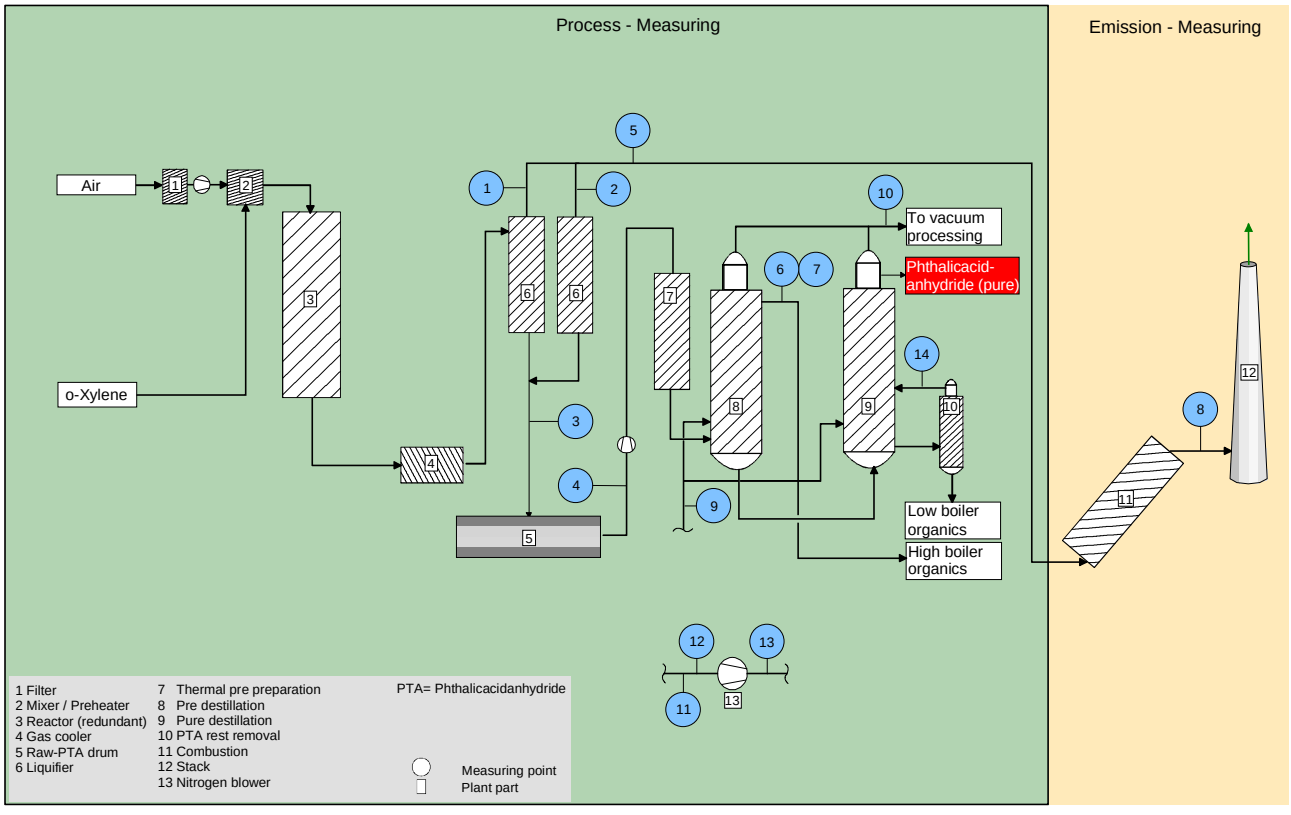
Measuring objectives

One important objective of PTA technology is to reduce energy consumption as far as possible. This can be achieved by increasing the o-xylene concentration in the process air, which, however, may cause, that the limit of flammability of the air/o-xylene mixture is exceeded with the danger of generating explosive conditions. Therefore, the entire process must be controlled by analyzing oxygen and some other gases continuously with highest care and, at several measuring locations, with high redundancy.

Typical steps of processing PTA from o-xylene (see flow chart)

- **Introduction** of preheated o-xylene into a stream of hot air.
- Flow of the o-xylene - air mixture through a **turbular reactor** with exothermic oxidation on a selective catalyst. Steam is produced here in excess which is utilized in the plant.
- **Precooling** of the gases leaving the reactor and feeding to a switch condensor system.
- **Condensation** of PTA in the condensor as a solid. The condensors are cooled and heated in a switching cycle.
- **Melting** of the solid PTA during the heating cycle of the switch-condensor and transfer as crude material into a storage tank.
- **Post treatment** and purification by two-stage **distillation.**
- **Incineration** of the waste gas.

PTA Production Process (Flow chart)



PTA production process flow chart

Sampling points and measuring tasks

MP	Sampling point location	Process stream	Measuring task	Measuring Compon.	Measuring range	Equipment
1	Condensor A discharge	Process gas	Plant safety	O_2	0 ... 10%	OXYMAT 6
1	Condensor A discharge	Process gas	Plant safety	O_2	0 ... 10%	OXYMAT 6
1	Condensor A discharge	Process gas	Plant safety	O_2	0 ... 10%	OXYMAT 6
1	Condensor A discharge	Process gas	Plant safety	CO CO_2	0 ... 2% 0 ... 10%	ULTRAMAT 6
1	Condensor A discharge	Process gas	Product quality	Diverse HC		PGC 302 Ed. II
2	Condensor B discharge	Process gas	Plant safety	O_2	0 ... 10%	OXYMAT 6
2	Condensor B discharge	Process gas	Plant safety	O_2	0 ... 10%	OXYMAT 6
2	Condensor B discharge	Process gas	Plant safety	O_2	0 ... 10%	OXYMAT 6
2	Condensor B discharge	Process gas	Plant safety	CO CO_2	0 ... 2% 0 ... 10%	ULTRAMAT 6
2	Condensor B discharge	Process gas	Product quality	Diverse HC		PGC 302 Ed. II
3	Condensor A+B discharge	Process medium	Plant safety	O_2		OXYMAT 6
3	Condensor A+B discharge	Process medium	Plant safety	O_2		OXYMAT 6
3	Condensor A +B discharge	Process medium	Plant safety	O_2		OXYMAT 6
3	Condensor A + B discharge	Process medium	Plant safety	CO CO_2	0 ... 2% 0 ... 10%	ULTRAMAT 6
3	Condensor A + B discharge	Process medium	Product quality	Diverse HC		PGC 302 Ed. II
4	Behind tank	Process medium	Product quality	Diverse HC		PGC 302 Ed. II

List of sampling points and measuring tasks (1)

MP	Sampling point location	Process stream	Measuring task	Measuring Compon.	Measuring range	Equipment
5	Exhaust gas from seperator	Exhaust gas	Plant safety	O_2	0 ... 8%	OXYMAT 6
6	Process medium discharge	Process gas	Plant safety	O_2	0 ... 8%	OXYMAT 6
7	Process medium discharge	Process gas	Plant safety	O_2	0 ... 8%	OXYMAT 6
8	Between incineration and stack	Flue gas	Plant safety Emission control	O_2	0 ... 15%	OXYMAT 6
9	Blower suction	Process gas	Plant safety	O_2	0 ... 8%	OXYMAT 6
10	Seperator change	Process gas	Plant safety	O_2	0 ... 8%	OXYMAT 6
11	Nitrogen intake compressor	Pure nitrogen	Plant safety	O_2	0 ... 8%	OXYMAT 6
12	Service suction compressor	Pure nitrogen	Plant safety	O_2	0 ... 8%	OXYMAT 6
13	Service suction outlet compressor	Pure nitrogen	Plant safety	O_2	0 ... 8%	OXYMAT 6
14	Process fluid to distillation	Process gas	Plant safety	O_2	0 ... 8%	OXYMAT 6

List of sampling points and measuring tasks (2)

Application of Siemens Analyzers

The following analyzers manufactured by Siemens are highly qualified and successfully tested for use in PTA plants:

- OXYMAT 5/6 field unit for analyzing O_2
- ULTRAMAT 5/6 field unit for analyzing CO and CO_2
- Process Gas Chromatograph P302 edition II for analyzing hydrocarbons

Series 6 gas analyzer in field housing

The **OXYMAT 6** is a gas analyzer that operates according to the paramagnetic principle and is designed for high-precision measurements of oxygen concentrations in gases. Thanks to the alternating pressure method and use of the resultant gas flow as a measurement variable as well as the micro flow sensor, the OXYMAT 6 does not contain any moving parts. The measuring gas also does not come into contact with the microflow sensor, thus ensuring an extremely long life time and high operating stability.

OXYMAT 6 features	**OXYMAT 6 benefits**
Simple and robust design without moving parts.	High operating reliability and life time. Very fast response time (T90). Very low maintenance and spare parts requirements, high availability.
Strictly linear measuring principle.	High measuring precision and flexibility.
Measuring principle allows differential measurement with a freely definable comparison gas concentration. No electronic zero suppression.	Very small measuring ranges for high (absolute) concentrations and thus very high measuring precision.
Minimum drift (0,5 % of span in 3 months).	Very high measuring precision Seldom needs recalibration.
Modifications using special materials available	Very long lifetime using tantalum or titanium for parts of the measuring system.
SIPROM GA software package for remote control and maintenance. Interface for PROFIBUS PA (Option).	Easily integrated into automated systems.

OXYMAT 6 features and benefits

The **ULTRAMAT 6** is a gas analyzer that operates according to the non-dispersive infrared principle (NDIR). It is designed to conduct highly selective concentration measurements of infrared-sensitive gases. The ULTRAMAT 6 uses the two-beam alternating light principle with a measurement and comparison cell, dual-layer detector, and optical coupler to achieve a high level of selectivity (minimization of cross sensitivity).

ULTRAMAT 6 features	ULTRAMAT 6 benefits
Dual-layer detector with variable optical path length setting (Optocoupler).	Maximum selectivity and measuring precision. Can be optimized for analysis task.
Detector uses microflow sensor with no moving parts to generate the measuring signal.	No microphony effects; very low signal noise; high measuring accuracy.
Extremely robust mechanical design. Electronics contained in same housing.	Very high operational reliability and life time.
SIPROM GA software package for remote control and maintenance. Interface for PROFIBUS PA (Option).	Easy integration in automated systems.
Can be extended for simultaneous measurement of 1-4 NDIR gas components. Can be combined with the OXYMAT 6 Oxygen Analyzer in one housing.	Lower costs thanks to processing of several measuring tasks with one device.

ULTRAMAT 6 features and benefits

The **PGC 302 edition II** is a dual-channel single or double-oven gas chromatograph designed for installations in hazardous and non hazardous areas. Its double-oven technology, a large selection of detectors, separating columns, and evaluation methods as well as its valveless column switching makes the PGC 302 an extremely powerful and flexible chromatograph.

PGC 302 edition II features	PGC 302 edition II benefits
Single or double-oven device with 1 or 2 channels for use in hazardous/non hazardous areas	Optimum adaption to analysis taks, extremely cost efficient
Can be retrofitted to include second oven	Low-cost expansion capability
5 detectors, including highly sensitive HID for measuring traces in high purity gases	Highly flexibel for optimum adaption to analysis tasks
Several evaluation methods, including area normalization, internal and external standard, 100% method	Extremely precise analysis results
Valveless column switching	Extended analysis capabilities, low maintenance requirements

PGC 302 edition II features and benefits

Customer value

Process analyzers in a PTA plant are of extreme importance for correct and safe plant operation. The analyzers themselves must be of very high quality and reliability and their integration into the plant requires a high level of know how and engineering expertise. Siemens can provide the customer with an, in both aspects, outstanding performance and value, because

- all required analyzers are manufactured by Siemens and known for their utmost quality and
- Siemens as system supplier has solved the PTA application several times successfully and has thus achieved intensive experience.

Process Gas Chromatograph PGC 302 edition II

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