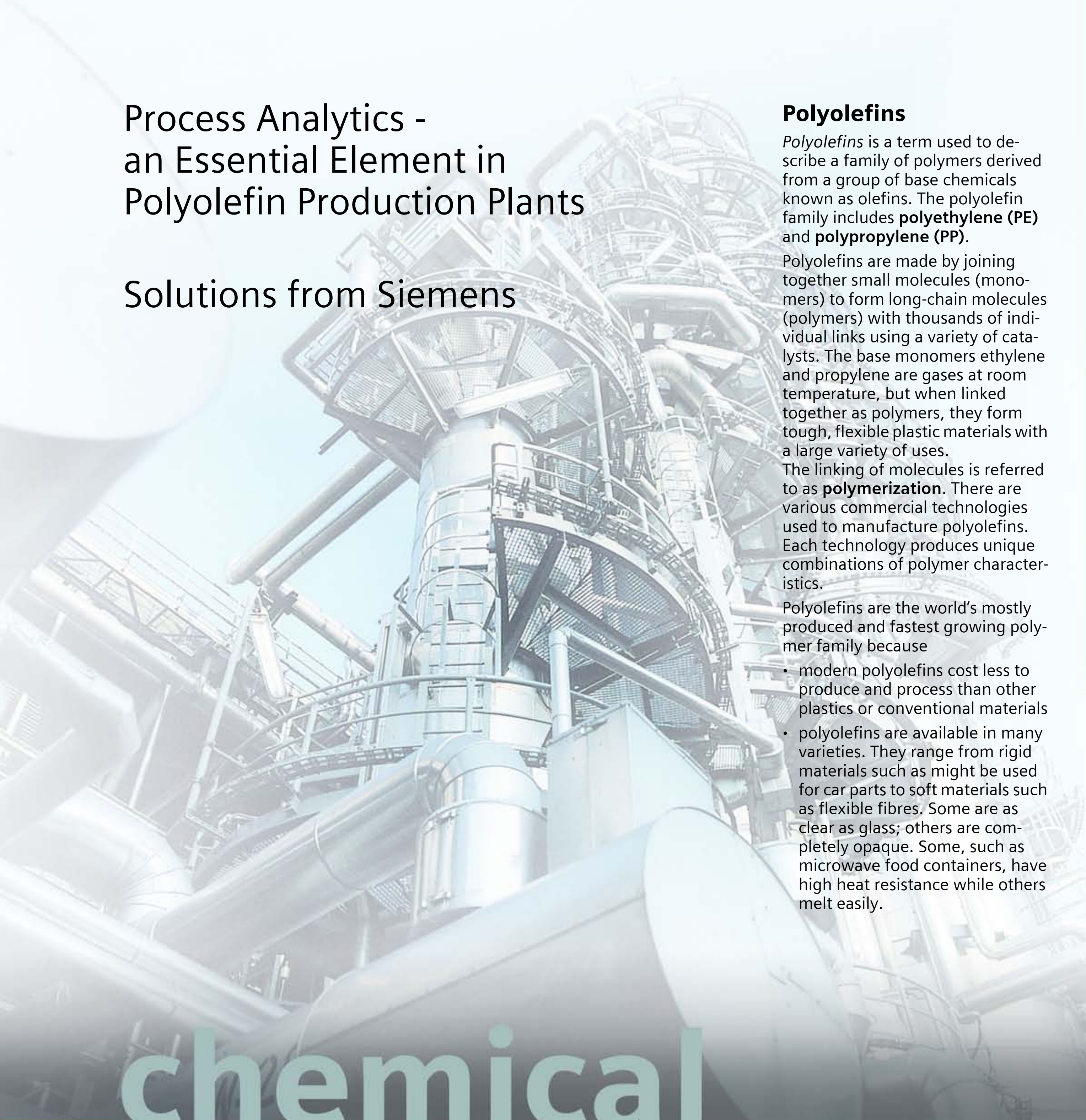

Process Analytics - an Essential Element in Polyolefin Production Plants

Solutions from Siemens

Case Study · January 2005

Polyolefins

Polyolefins is a term used to describe a family of polymers derived from a group of base chemicals known as olefins. The polyolefin family includes **polyethylene (PE)** and **polypropylene (PP)**.

Polyolefins are made by joining together small molecules (monomers) to form long-chain molecules (polymers) with thousands of individual links using a variety of catalysts. The base monomers ethylene and propylene are gases at room temperature, but when linked together as polymers, they form tough, flexible plastic materials with a large variety of uses.
The linking of molecules is referred to as **polymerization**. There are various commercial technologies used to manufacture polyolefins. Each technology produces unique combinations of polymer characteristics.

Polyolefins are the world's mostly produced and fastest growing polymer family because

- modern polyolefins cost less to produce and process than other plastics or conventional materials
- polyolefins are available in many varieties. They range from rigid materials such as might be used for car parts to soft materials such as flexible fibres. Some are as clear as glass; others are completely opaque. Some, such as microwave food containers, have high heat resistance while others melt easily.

chemical INDUSTRY

For the **production of polyolefins** a variety of different process types are used depending on what final products are intended to be produced. However, regardless of the process type used, all plants require **process analytical equipment** to collect reliable and accurate information for process control, product quality, and plant safety. Siemens, a leader in process analytical instrumentation, has proven over decades its capability to plan, engineer, manufacture, implement and service analyzer systems for polyolefin plants worldwide.

This *Case Study* provides an overview of the processes typically used and describes how Siemens, using its outstanding analyzer technology, application know-how and system integration expertise is able to meet best the process requirements and to offer remarkable user benefits.

SIEMENS

Polyolefins production technologies

Polyolefins

are made in a polymerization reaction by building long molecular chains comprised of ethylene or propylene monomers, mostly by using catalysts. The type and nature of the catalysts are of great influence on the polymerization. As catalysts became more efficient, the polyethylene and polypropylene products became purer and more versatile and the production process became simpler and more efficient.

Polyethylene (PE)

is a family of resins made from the polymerization of ethylene gas. It is produced either in radical polymerization reactions or in catalytic polymerization reactions. Most PE molecules contain „branches“ in their chains which are formed spontaneously in case of radical polymerization or deliberately by copolymerization of ethylene with α–olefins in case of catalytic polymerization.

PE resins are classified according to their density which partly depends on the type of branching.

- **HDPE**
  High **D**ensity **P**oly**E**thylene has almost no branching and thus has stronger intermolecular forces. It is produced mainly in slurry and gas-phase polymerization processes. HDPE is a white opaque solid.
- **MDPE**
  Medium **D**ensity **P**oly**E**thylene has a high degree of resistance to chemicals and is very easy to keep clean.
- **LDPE**
  Low-**D**ensity **P**oly**E**thylene has random long branching, with branches on branches. It is produced mainly in high-pressure poymerization processes. LDPE is a translucent solid.
- **LLDPE**
  Linear **L**ow-**D**ensity **P**oly**E**thylene is a substantially linear polymer, with significant numbers of short branches, produced mainly by copolymerization of ethylene with longer-chain olefins. LLDPE is a translucent solid.

Polypropylene (PP)

Polypropylene is a tough, rigid plastic and produced in a variety of molecular weights and crystallinities. Three main types of PP exist:

- **Homopolymers**, which have high heat resistance and good rigidity, making them suitable for a wide range of applications
- **Copolymers**, which are made by incorporating different monomers, are extremely resilient materials and are widely used in automotive and industrial applications
- **Random copolymers**, which are made by introducing ethylene links into the PP-chain, have improved optical properties such as transparency.

Production Processes

A large number of production processes exist for PE and PP with some general similarities. But the processes for the different types of polymers and the different types of production plants are evolving continuously. So the specifics can be significantly different. Therefore, the following descriptions and graphic displays should be considered exemplarily only with no direct relation to existing plant or process designs.

Generic polymerization process

Similarities between the processes follow a generic olefin polymerization process scheme as shown in Fig. 1 (from left):

- Feedstock materials and additives must be purified and catalyst material must be prepared. And - in case of a high pressure process - the gas must be compressed in several stages.
- Polymerization takes place either in the **gas phase** (fluidized bed or stirred reactor), the **liquid phase** (slurry or solution), or in a **high pressure** environment. Polymerization is the heart of the processes. On any one unit, only one of the three processes is used. More details will be explained on the next pages.
- Polymer particles are then separated from still existing monomers and diluent, pelletized, dried and dispatched.
- Monomers and diluents are recovered and fed again to the process.

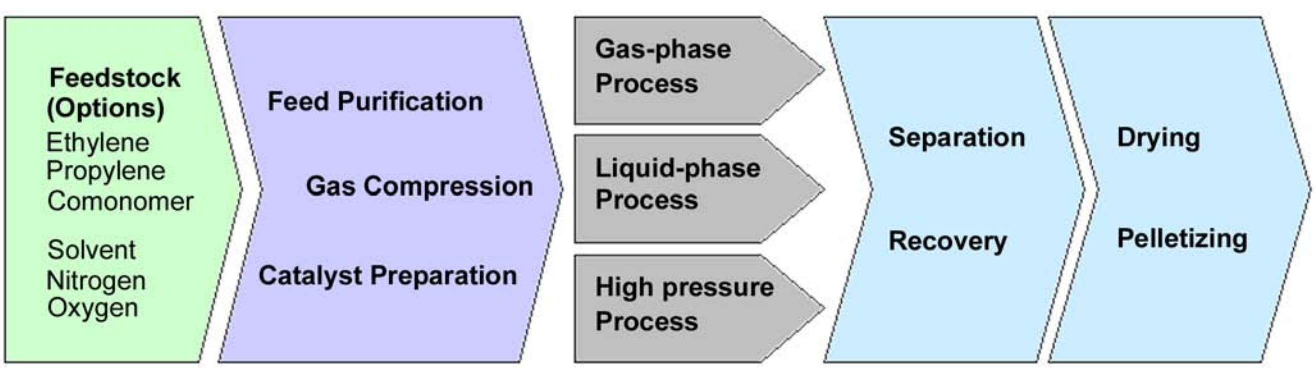

Fig. 1: Generic olefin polymerization process (simplified)

Polymerization in gas phase

Gas-Phase Polymerization

In gas-phase polymerization ethylene or propylene is contacted with solid catalyst material intimately dispersed in an agitated bed of dry polymer powder. Two different methods are used to carry out this reaction

- In the *fluidized-bed process* (Fig. 2) the monomer flows through a perforated distribution plate at the reactor bottom and rapid gas circulation ensures fluidization and heat removal. Unreacted polymer is separated from the polymer particles at the top of the reactor and recycled. Fluidized-bed plants are able to produce either LLDPE or HDPE and are free of constraints from viscosity (solution process) or solubility (slurry process). A modification uses a second reactor connected in series to perform copolymerization. For copolymerization: See glossary.
- The *stirred-bed process* uses a horizontal or vertical reactor with compartments, in which the bed of polymer particles is agitated by mixing blades.

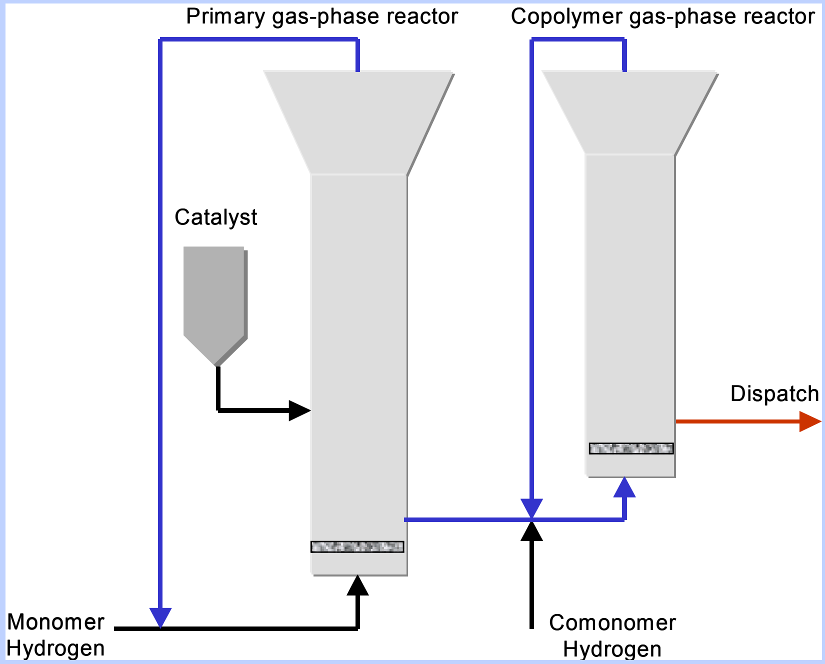

Fig. 2: Gas-phase fluidized-bed process with two reactors in

The gas-phase polymerization technology is economical and flexible and can accomodate a large variety of catalysts. It is by far the most common process in modern polyolefin production plants, see Fig. 3.

Gas-phase processes	
Lupotech G®	A fluidized-bed process for the production of HDPE, MDPE, and LLDPE
Unipol® PE	A fluidized-bed process for the production of HDPE and LLDPE
Unipol® PP	A fluidized-bed process with one or two reactors for the production of PP homopolymers, random polymers and impact polymers.
Novolen®	A gas-phase stirred-bed process with two reactors in series for the production of PP

Fig. 3: Gas-phase processes (selected)

Polymerization in liquid phase or in a high pressure environment

Liquid-Phase Polymerization

In liquid-phase (slurry or suspension) processes catalyst and polymer particles are suspended in an inert solvent, typically a light or heavy hydrocarbon. Super-critical slurry polymerization processes use supercritical propane as diluent.
Slurry processes run in loop reactors with the solvent circulating, stirred tank reactors with a high boiling solvent or a "liquid pool" in which polymerization takes place in a boiling light solvent. A variety of catalysts can be used in these processes. Processes in solution require, as their last step, the stripping of the solvent.

Supercritical polymerization in the slurry loop provides advantages (e.g. higher productivity, improved product properties) over subcritical polymerization.

Advanced processes combine a loop reactor with one or two gase-phase reactors, placed in series, where the second stage of the reaction takes place in the gas-phase reactors (Fig. 6). For bimodal polymers, lower molecular weights are formed in the loop reactor, while high molecular weights are formed in the gas-phase reactor.
Some common processes are listed in Fig. 4

High Pressure Processes

In high pressure processes *autoclave or tubular reactors* (pressure in excess of 3,000 bar) are used, but the processes are similar, comprising compression, polymerization, pelletizing, and dispatch as major steps. Fresh ethylene enters the reactor and is mixed with the low pressure recycle. After further compression the mixture enters the reactor for polymerization. Oxygen or peroxide may be used as initiators.

A tubular reactor (Fig. 7) typically consists of several hundred meters of jacketted high-pressure tubing arranged as a series of straight sections connected bey 180° bends.

High pressure processes can produce LLDPE homopolymers and vinylacetate copoymers in addition to the normal range of LDPEs.

Some processes are listed in Fig. 5.

Liquid-phase processes	
Hostalen®	A low-pressure slurry process for the production of bimodal HDPE
Borstar® PE	A supercritical slurry process, which combines a loop reactor and a gas-phase reactor
Borstar® PP	A supercritical slurry process, which combines a loop reactor with two gas-phase reactors
Spheripol®	A slurry process for the production of PP homopolymer plus random copolymers
Phillips	A slurry process for the production of HDPE

Fig. 4: Liquid-phase processes (selected)

High pressure processes (selected)	
Lupotech T®	High-pressure process for the production of broad range LDPE
ExonMobil	High-pressure tubular process for LDPE
Equistar	High-pressure tubular and autoclave processes for LDPE

Fig. 5: High pressure processes (selected)

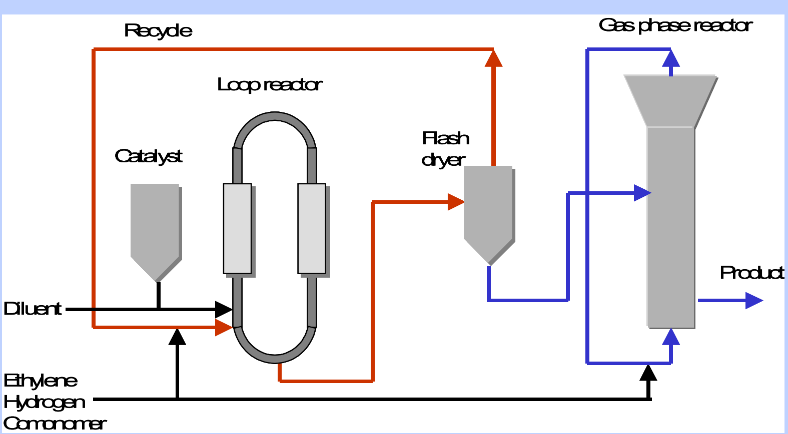

Fig. 6: Slurry process, combined with gas-phase second stage

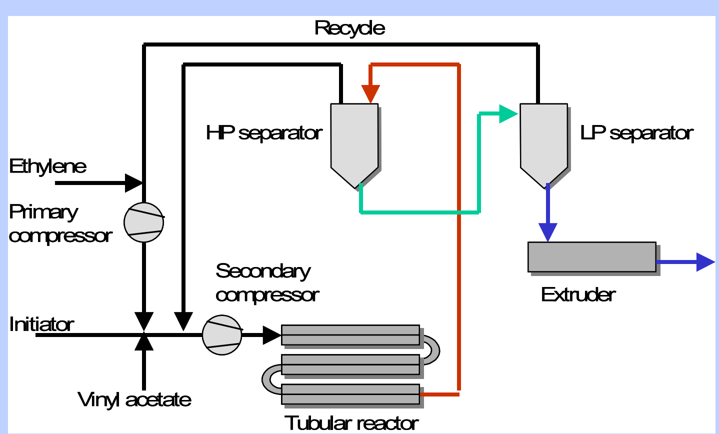

Fig. 7: High-pressure tubular reactor process

Use of process analyzers in olefin polymerization plants

Analyzer Tasks

Process analytical equipment is an indispensable part of any polyolefin plant because it provides the operator and the control system with key data from the process and its environment.

Four major applications

Analyzer applications can be divided in three groups depending on how the analyzer data are used:

- **Closed-loop control for process and product optimization**
  This application helps to increase yield, reduce energy consumption, achieve smooth operation, and keep product quality accoding to the specification
- **Quality control and documentation** for ISO compliance
- **Plant monitoring and alarms**
  This application protects personnel and plant from possible hazard from toxic or explosive substances
- **Emission control**
  This application helps to keep emission levels in compliance with local regulations.

Analyzers and sampling points

Different analyzers are used in polyolefin plants ranging from simple sensor type monitors to high technology process gas chromatographs.
The list typically includes

- Process gas chromatographs
- Continuous gas analyzers (paramagnetic oxygen analyzers, NDIR analyzers, total hydrocarbon content analyzers)
- Analyzers for moisture and O_2 traces
- Low Explosion Level (LEL) analyzers

Analyzer installations

Analyzers are installed partially in the field close to the sampling location and/or in an analyzer house (shelter). In modern plants most of the analyzers are interfaced to a plant wide data communication system for direct data transfer from and to the analyzers.

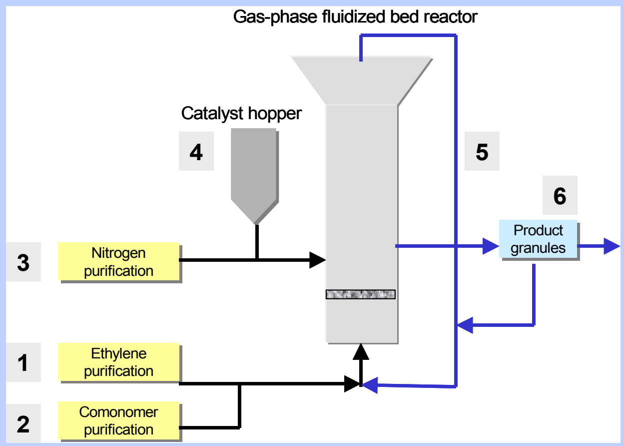

Fig. 8: Sampling points of a fluidized-bed HDPE plant

The total **number of analyzers** installed in a plant varies from plant to plant depending on the type of process, individual plant conditions and user requirements.

An example of **typical sampling locations**, analyzers, and measuring components and ranges is given in Fig. 8 and 9 for a HDPE plant using a gas-phase fluidized bed reactor:

- Feed of monomer, comonomers, catalyst, and additives to the reactor (1-4)
- Cycle gas line (5)
- Product line or feed to a second reactor (6)
- Safety measurements at different locations (not shown in Fig. 8)

Sampling point	Component	Range [ppm]	Sampling point	Component	Range [%]
1 Ethylene purification	CO	0 - 2	5 Cycle gas	Nitrogen	0 - 100
	CO_2	0 - 2		Hydrogen	0 - 50
	Methanol	0 - 10		CO	0 - 10/200 ppm
	Acetylene	0 - 5		Methane	0 - 10
	S	0 - 2		Ethane	0 - 20
	Ethane	0 - 400		Ethylene	0 - 100
	Water	0 - 5		N-Butane	0 - 5
	O_2	0 - 2		ISO-Butane	0 - 5
2 Comonomer purification	Water	0 - 100		1-Butene	0 - 25
3 Nitrogen purification	Water	0 - 10		Trans-2-Butene	0 - 1
	O_2	0 - 10		ISO-Butene	0 - 5
4 Catalyst feed	O_2	0 - 10 %		CIS-2-Butene	0 - 2
6 Product	Water	0 - 5		Hexane	0 - 10
				1-Hexene	0 - 20
				C6 inerts	0 - 10

Fig. 9: Typical measuring components and ranges according to Fig. 8

Siemens Process Analytics

Siemens Process Analytics is a leading supplier of process analytical instrumentation and services, with competence centers in Germany, Singapore and the United States.

Besides its wide variety of high performance process analyzers (see Fig. 10) , Siemens Process Analytics supplies analyzer systems including engineering and manufacturing, commissioning, service and maintenance. Siemens is able to design and deliver customized solutions and thus to support the user in making process and plant operation as efficient and economical as possible. As part of turn-key solutions Siemens will also specify and implement third party analyzer equipment and service and warrant those systems. So the user can rely on just one single partner from project conception to plant start-up.

In all polyolefin plants, of what ever process type, gas chromatographs are the most important analyzers followed by continuous gas analyzers and LEL gas monitoring systems.

Siemens Process Analytics	
Process Gas Chromatographs	• MAXUM Edition II Gas Chromatograph, leading the industry in capability, flexibility, and reliability • MicroSAM, the new process gas chromatograph, powerful and compact, to be installed directly at the sampling point
Continuous Gas Analyzers	• Series-6 gas analyzers, comprising OXYMAT 6, ULTRAMAT 6, CALOMAT 6 and FIDAMAT 6 • ULTRAMAT 23 multicomponent gas analyzer • LDS 6 in-situ diode laser gas analyzer
Process Spectrometers	• QUANTRA the ion cyclotron resonance mass spectrometer
System Integration	• Full capability to plan, engineer, implement and service process analytical systems worldwide • Workshops in Germany, Singapore and the USA

Fig. 10: Product overview

MAXUM™ edition II Gas Chromatograph

MAXUM Edition II (Fig. 13) represents the top technology in process gas chromatography with unparalleled features resulting in a high versatility to solve any given application task with best possible analytical results at lowest costs. Remarkable features include

- Multiple analytical tools such as ovens, detectors, valves etc.
- Parallel chromatography
- Valveless chromatography
- Graphical Human Machine Interface
- Complete networking capabilities
- Powerful processing software

MicroSAM

MicroSAM (Fig. 11), the newest on-line process gas chromatograph from Siemens, combines miniature size with powerful technology, complete system capabilities and simple operation. Significant advantages include

- Less space, less electrical power, less sampling requirements, installed directly at the sampling point
- Turnkey shipment, ready to mount
- Less maintenance effort because of modular design
- Better process control by drastically reduced cycle times

Fig. 11: MicroSAM gas chromatograph

Series 6 Gas Analyzers

Siemens series 6 process analyzers (Fig. 12) use different physical measuring techniques depending on the application. Besides the extractive sampling based analyzers (ULTRAMAT, OXYMAT, FIDAMAT, CALOMAT) series 6 has been expanded in 2004 by addition of the in-situ laser gas analyzer LDS 6.
Series 6 gas analyzers are well known in the process industry for their quality, reliability, measuring accuracy and long service life. Optimum solutions are available for all applications, e.g. rack or field mounting, explosion protection, corrosion resistant versions and various communication types.

For all series 6 process analyzers and the ULTRAMAT 23, Ethernet is available as a common communication platform via the TCP/IP protocol or the field bus system PROFIBUS.

Fig. 12: Series 6 gas analyzer, field housing

Solutions from Siemens Process Analytics (1)

Process Gas Chromatography

Siemens has the right solution for every application: **MicroSAM** is designed for standard applications and provides a very fast and economic solution especially if the analyzer is “field mounted” close to the sampling point without any shelter. For more complex applications, the high-end process gas chromatograph **Maxum Edition II** provides unparalleled features and capabilities as described in the following sections.

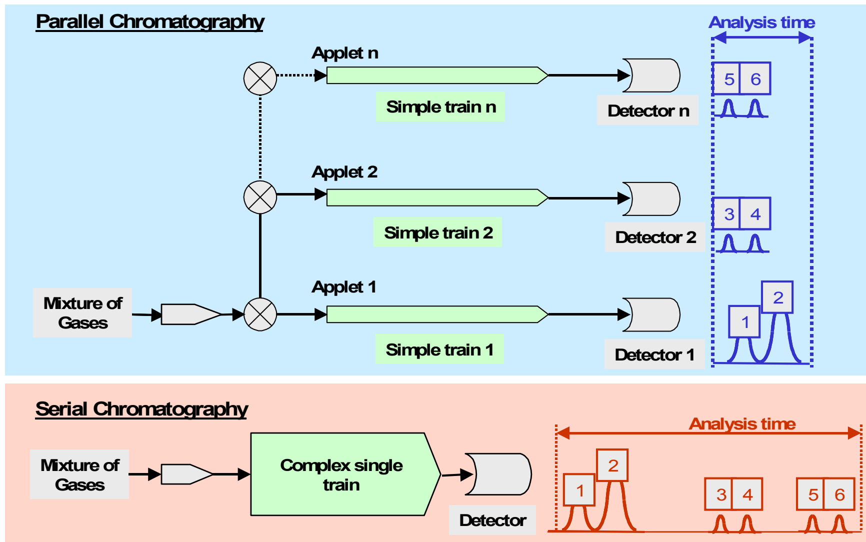

Fig. 14: Principle of Parallel Chromatography with serial analysis (below) and parallel analysis (above)

Fig. 13: MAXUM Edition II

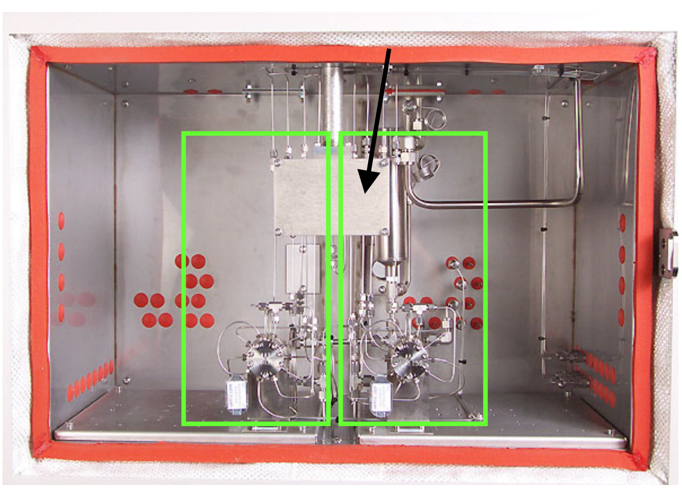

Fig. 15: MAXUM´s double oven with two applets

Parallel Chromatography

Maxum II provides a completely new approach to gas chromatography, named *Parallel Chromatography*. With Maxum´s hardware and software tools, a complex *single train* analysis can be broken into *multiple very simple single trains* (Fig. 14). Each of the single trains, called *Applets*, run in parallel, which reduces cycle time compared to a seriell run in conventional chromatographs. This is in particular important for measurements where a short response time is required to maintain optimal process conditions.

Applets may be standardized for common applications and can be configured alone or in parallel groups, depending on the actual application task (Fig. 15).

Solutions from Siemens Process Analytics (2)

MAXUM Dual Oven and Parallel Chromatography

Parallel Chromatography in combination with MAXUMs flexible dual oven concept provides unmatched capabilities to solve complex analytical tasks , see Fig. 16:

As much as 22 different componets in two sample streams (cycle gas and ethylene from purification) are analyzed in parallel by using only two dual oven chromatographs. They are equipped with in total 9 applets from only 5 standardized types *(applets A to E)*, each comprizing an optimized set of injector, column and detector.

The advantages are quite evident:

- Best possible analytical results from using application-optimized applets
- Minimized investment and maintenance costs by dual oven concept
- Minimized cycle time by parallel analysis

			Cycle gas		Ethylene from purification	
Applet	Component	Range [%]	PGC 1		PGC 2	
			Oven 1	Oven 2	Oven 1	Oven 2
Type A	H_2	0 - 50	x			
	CO	0 - 2 ppm				x
	CO_2	0 - 2 ppm				x
Type B	N_2	0 - 100	x			
	Methane	0 - 10	x			
	Ethane	0 - 20	x			
	Ethene	0 - 100	x			
	Ethene	0 - 100				x
	N_2	0 - 100				x
Type C	n-Butane	0 - 5		x		
	i-Butane	0 - 5		x		
	1-Butene	0 - 25		x		
	t-Butene	0 - 1		x		
	c-Butene	0 - 2		x		
	i-Butene	0 - 5		x		
	Methanol	0 - 10 ppm			x	
Type D	n-Hexane	0 - 10		x		
	1-Hexene	0 - 20		x		
	C_6-Inerts	0 - 10		x		
	Acetylene	0 - 5 ppm			x	
	Ethane	0 - 400 ppm			x	
Type E	CO	0 - 10/20	x			

Fig. 16: Example for Parallel chromatography using applets in two dual oven chromatographs (PE plant)

GC Networking Capabilities

MAXUM is a distributed analyzer system using industry standard protocols for communication (Fig. 17). This provides high-speed communication between all devices. The Maxum communication system can function alone or may be connected to a DCS or a plant wide LAN and can also be connected to existing Advance Data Hiway and ChromLAN systems.

Features summary:

- Maxum is a completely distributed analyzer system
- Stand Alone or with a Workstation, DCS or plant-wide LAN
- TCP/IP protocol open communications to all Networks
- Single or redundant communications for lowest cost
- Backward compatibility supports connection to installed networks
- MODBUS, ODBC and OPC for connection to other IT-systems

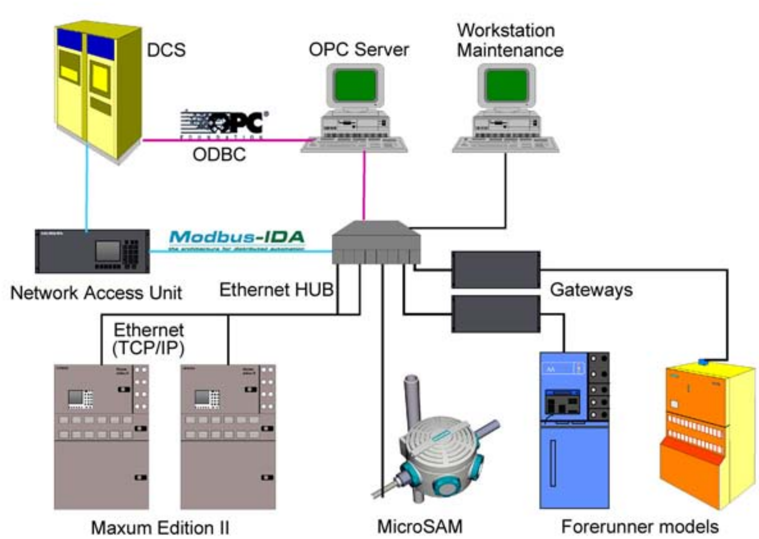

Fig.17: MAXUM II and MicroSAM chromatographs in a comminication network

Solutions from Siemens Process Analytics (3)

Continuous Gas Analyzers

Continuous gas analyzers (CGA) are used for different application tasks which often vary from plant to plant depending on process and plant specifics or on e.g. explosion protection or air and water pollution control regulations.

Typical applications are

- Measurement of oxygen (% range) to protect from the danger of explosion by controlling the O_2 content in different process streams continuously. The OXYMAT 6 is especially ATEX certified for this application, see below.
- Measurement of CO and CO_2 in waste gas to assure their concentration to be in compliance with the emission limit values
- Measurement of O_2 (ppm range) in selected process streams (feed, loop, product) to assure process efficiency and product quality
- Measurement of humidity (H_2O) in all main process streams for process optimization (e.g to prevent catalyst poisoning) and product quality control

Sampling points	Component	Range	Siemens Solution
Decanter off gas	O_2	0 - 1 %	OXYMAT 6/61
Drying gas to dryer	O_2	0 - 1%	OXYMAT 61 + O_2-Transmitter
	O_2	0 - 100 ppm	
Drying gas from dryer	H_2O	0 - 100 ppm	Third party product
Conveying nitrogen	H_2O	0 - 1000 ppm	Third party product
	O_2	0 - 1 %	OXYMAT 61 + O_2-Transmitter
	O_2	0 - 100 ppm	
	C_6H_{14}	0 - 100 % LEL	Third party product
Waste gas	CO	0 - 0,5 %	ULTRAMAT 23 / ULTRAMAT 6
	CO_2	0 - 0,5 %	
	Combustibles	0 - 50 % LEL	Third party product
Waste water tank	O_2	0 - 1 %	OXYMAT 6/61
Waste water channel	Combustibles	0 - 50 % LEL	Third party product
Extruder inlet	O_2	0 - 1 %	OXYMAT 6/61

Fig. 18: Sampling points for continuous gas analyzers (typical set up)

Fig. 18 shows typical sampling points for continuous analyzers in a HDPE plant together with measuring components and relevant Siemens analyzers and Fig. 19 a typical CGA installation.

Fig. 19: CGA installation

LEL Analyzers

Mixtures of combustible substances and air or oxygen are explosive in certain concentration ranges. For each concentration mixture, low (LEL) and high (HEL) explosion limits are specified that depend on the temperature and pressure of the gas. Special gas detectors are used to monitor substances such as hydrogen, ethylene, propylene, CO and O_2 to prevent the atmosphere inside or outside the analyzer house from reaching the LEL.
Gas detectors are typically part of the safeguarding system of the analyzer house to minimize the exposure of personnel to flammable or toxic hazads.

OXYMAT 6: ATEX 95 certified

The OXYMAT 6 oxygen gas analyzer has been successfully tested in accordance with the ATEX 95 directive provisions by the certification body of Deutsche Montan Technologie GmbH (DMT).
The EC-type Certificate comprises the OXYMAT in either the rack or the field housing version.
The certificate confirms the use of the the OXYMAT 6 in industrial areas (group II) in zones 1 or 2 (category 2) with danger of explosions caused by gases (G). Because of its measuring principle and construction design, OXYMAT 6 provides in this respect a singular high level of safety to the user.

System integration

Fig. 20: Analyzer shelter

System Integration

Analyzers from Siemens are known for their high availability, long life cycle and measurement precision. In order to maximize the benefits of these properties, it is required to integrate the analyzers into an ideal and safe environment. This includes sample handling and conditioning, safeguarding equipment and utilities, as well as signal processing and data communication.

Siemens has been a reliable partner in the construction of analyzer systems for over 30 years. We supply front end engineering services and complete turnkey systems and shelters along with start-up, commissioning and training services.

Blend of Expertise

As a manufacturer of analyzers and instruments and as an automation specialist, Siemens provides a unique blend of analytical expertise, process and process control knowledge. Depending on the needs of the application, Siemens can supply new and innovative solutions or can use solutions that have been of proven value for many years. As a matter of course, Siemens integrates its own analyzers as well as third-party analyzers.

Our logistic specialists have expert knowledge in handling and shipping analyzer systems and spare parts worldwide. Thanks to our worldwide service-network, our specialists and spare parts get expeditiously to your site.

Through all stages of the project, a designated Siemens project manager operates as your single point of communications and responsibility. Finally, our customers receive a complete analyzer system from a single source with the warranty for the whole system.

Range of Services

Our range of services is not limited to engineering and assembly of your analytical system. We also support you in the planning and basic engineering of your analytical system and communication network.

But also in the settlement of your project, you can count on us: Our well-rehearsed and optimized work flow ensures short lead times and real-time control of costs. That way, we guarantee that your project is on time and on budget – with no surprises.

At Siemens, all units exist under one umbrella. Thus, we have direct access to our workshops, our analyzer production lines as well as our R&D and application labs. This ensures high flexibility and short reaction time.

Globally on Site

Siemens operates system integration centers in Karlsruhe, Houston and Singapore. Furthermore, we are currently building up an all new solution center in Shanghai. In this way, we are present globally and acquainted with all respective local and regional requirements, codes and standards.

Each of these solution centers has its own support team, as well as its own engineering and assembly teams along with a sizeable workshop, service and training facilities.

For polyolefin production plants, Siemens has engineered, assembled and installed many analytical systems all over the world.

Houston, TX USA

Karlsruhe, Germany

Singapore

User benefits and Glossary

For cost and application efficient integration of process analyzers and analyzer system into a process plant, a partnership with Siemens Process Analytics provides remarkable benefits to the user:

- **Reliable, customized solutions** based on extensive analytical expertise, application and process knowledge for a wide variety of industries
- **Turn-key project handling** by a designated project manager, ranging from planning and basic engineering to system manufacturing, commissioning, training and after sales service
- **Worldwide support** everywhere and at all times from Siemens subsidiaries with analyzer specialists and additionally from the International Process Analytics Competence Centers.

In particular, in supplying polyolefin production plants with analyzers, turnkey analyzer systems and worldwide support, Siemens Process Analytics is very likely the most reliable and efficient partner:

- **Top level of analyzer technology** Almost all analyzers required in polyolefin plants are developed, manufactured, and customized by Siemens itself, which keeps Siemens continuously at the top of the fast growing analyzer technology.
- **Most extensive special expertise** Because of the unbeaten number of analyzers installed Siemens has very likely the most extensive expertise in solving the analytical taks arising from a polyolefine plant. This saves time and reduces costs from the very beginning of a project up to the maintenance phase in a running plant.

.

Polyolefin Production, Glossary	
Bimodal	Combination of a high molecular mass component with a low molecular weight mass component. Provides exceptional mechanical properties
Block polymer	All of one type of monomer are grouped together
Catalyst	A substance, that together with the design of the production process, determines the nature of the polyolefin and the production efficiency. Typical catalysts are based on chromium oxides, organochromium compounds, titatnium or vanadium compounds and many others
Copolymer	A polymer with two different types of monomers in the same chain. The principal effect of copolymerization is to reduce crystallinity and to control resin density. α-olefins are mostly used as copolymers
Homopolymer	A polymer with just one type of monomers in the chain
MFI	Melt flow index, a measure of the melt characteristics
Monomer	A single molecule which can join with another monomer to form a polymer or molecular chain
Polyethylene (PE)	A family of resins made from polymerization of ethylene gas using a variety of catalysts. Modifications are obtained by co-polymers or additives
Polyolefines	A term to describe a family of polymers made from the base monomers ethylene and propylene. Polyolefines are resinous materials
Polypropylene (PP)	A plastic made from polymerization of propylene gas in the presence of an organometallic catalyst.
Random polymer	A copolymer where the two monomers in the chain may follow any order
Resin	Any of a class of solid or semisolid organic products with no definite melting point. Most resins are polymers

Case Study

If you have any questions, please contact your local sales representative or any of the contact addresses below.

Siemens AG
A&D PI 2 Process Analytics
Oestliche Rheinbrückenstr. 50
D-76187 Karlsruhe
Germany
Tel.: +49 721 595 4234
Fax: +49 721 595 6375

E-Mail: processanalytics@siemens.com
www.siemens.de/processanalytics

Siemens Applied Automation

500 West Highway 60
Bartlesville, OK 74003
USA
Tel.: +1 918 662 7000
Fax: +1 918 662 7052

E-Mail: saaisales@sea.siemens.com
www.sea.siemens.com/ia

Siemens Pte. Limited
A&D PI 2 Regional Headquarter
The Siemens Center
60 MacPherson Road
Singapore 348615
Tel.: +65 6490 8702
Fax: +65 6490 8703

E-Mail: splanalytics.sgp@siemens.com
www.siemens.com/processanalytics

Siemens AG
Automation and Drives (A&D)
Process Instrumentation and Analytics
D-76181 Karlsruhe

Order No. ...
Printed in Germany
.....