

The image shows two Siemens employees in hard hats and safety vests looking at a complex industrial gasification plant. The plant features a dense network of pipes, yellow railings, and large cylindrical vessels. The background is a clear blue sky.

Siemens Fuel Gasification Technology

Fuel gasification technology for Integrated Gasification Combined Cycle
and industrial applications

Answers for energy.

SIEMENS



High oil and gas prices have led to a resurgence of coal as an affordable energy source. Especially coal-rich regions have increasingly been tapping their local resources. This allows them to reduce their reliance on foreign imports of natural resources and at the same time achieving stable prices to meet ever growing energy demands.

Gasification offers one of the cleanest and most flexible ways of converting coal and low-grade fuels into high-value products – electricity, chemicals or synthetic fuels. Combining gasification with advanced gas turbines in Integrated Gasification Combined Cycle (IGCC) power plants results in a highly efficient technology for coal-based power generation.

Environmental requirements are becoming more and more stringent all over the world. Gasification

projects are attractive solutions as they can offer environmentally friendly plants with lower emissions and the combination with readily available technology for CO₂ Capture and Storage (CCS).

The Siemens Fuel Gasification (SFG™) technology continues a long-held Siemens tradition of satisfying the needs of our customers worldwide. High availability, low life-cycle costs and multi-fuel capability are among the most important factors for being competitive. The Siemens Fuel Gasification technology addresses all of these key competitive drivers. The technology is flexible with regard to feedstock and products, and can utilize all types of coal, ranging from anthracite to lignite, as well as refinery residues (petcoke and liquids), and biomass.



Siemens Fuel Gasifier

The entrained-flow Siemens Fuel Gasifier (SFG™) is able to convert a large range of fuels and is ideally suited for lower-rank fuels like lignite with high ash and moisture content. The syngas leaving the gasifier island mainly consists of CO, hydrogen and small amounts of CO₂ and is free of any higher hydrocarbons.

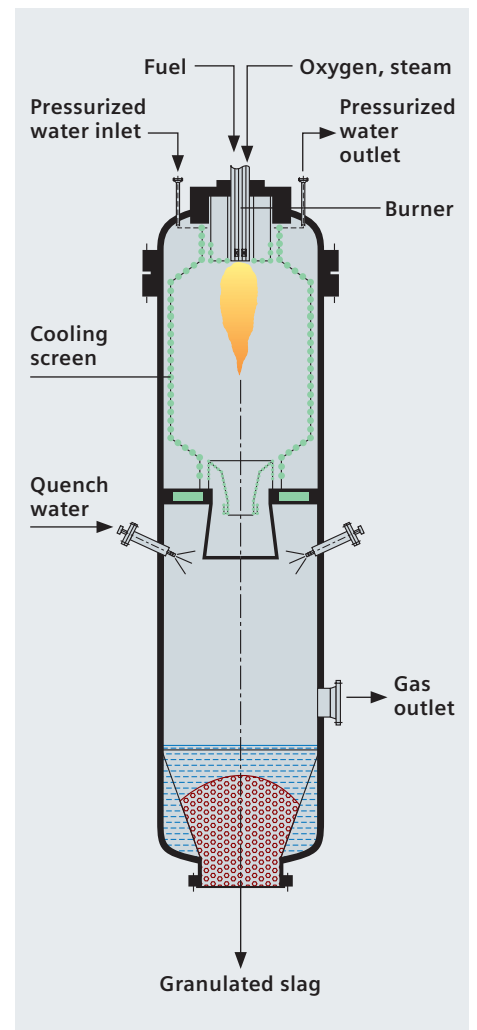
Noxious components such as particulates, sulfur and nitrogen compounds which are typical of gasification are removed by conventional gas treatment and conditioning processes downstream the gasification process.

Main features of Siemens Fuel Gasification technology:

- Dry solids feeding for high efficiency and low O₂ consumption
- Top-mounted dust burner with extended burner lifetime
- Cooling screen for high availability and low maintenance
- Full water quench for simple and reliable design

Benefits of Siemens Fuel Gasifier:

- Feedstock flexibility: Suitable for all kind of coal types, especially lignite, biomass, petcoke and liquid refinery residues
- High carbon conversion: > 98 %
- Operating pressures: 40 bar and above
- Shorter start-up times
- Smaller dimensions for reduced equipment costs
- High availability and low maintenance
- Proven experience: More than 20 years of successful operating experience





Design of Siemens Fuel Gasifier

The gasifier is equipped with a cooling screen, consisting of spiral-wound tubes filled with cooling water. Molten slag builds up a protection layer against the high reaction temperatures. Liquid slag from the reaction phase only comes in contact with the solidified slag layer, and hence no corrosion of the reactor wall can take place.

The cooling screen design ensures long gasifier availability periods before requiring repair or relining. This design has been in successful operation for over 12 years. Compared with a conventional refractory lining the cooling screen is insensitive to high ash content or fluctuating ash composition.

The gasifier can startup or shut down within few minutes. Cold startup can be done in less than two hours vs. refractory lined gasifiers which can take days to startup.

The reactor design with cooling screen is ideally suited for fuels with ash contents of more than 1-2 % by weight. For fuels with lower ash content like refinery residues, an alternative design with refractory wall is also available.

Gasification Process

The feedstock together with oxygen and steam is supplied via top-mounted burners. Conversion takes place at temperatures of around 1,300°C to 1,800°C (2,350°F to 3,250°F). These high temperatures, in combination with the dry feed system, allow for the almost complete conversion of the feedstock.

After the reaction chamber, raw gas and slag discharge into a quench section arranged beneath the reaction chamber. By injection of water the gas is cooled to temperatures of around 220°C (430°F) and the molten slag solidifies.

The vitrified slag granulates, accumulates in the water-filled quench bottom and discharges via a lock hopper. The slag is non-leachable and can be sold for use as building or road construction material.

Dry Feeding System

For solid fuels, a dry feeding is used, based on a pneumatic dense-phase feeding system. This makes the process more efficient and applicable to low-rank coals. Particle size distribution and moisture level depend on the type of feedstock used; typical ranges are below 0.5 mm and 2-12 % moisture.

Pulverized solid fuel is first supplied into lock hoppers and pressurized with a feeding gas like nitrogen or CO₂ to gasifier operating pressure. From there, it passes into a feeder vessel and further on into the gasifier. Dry feeding allows use of robust dust burners with lifetimes well above one year.



Siemens Fuel Gasifier Island

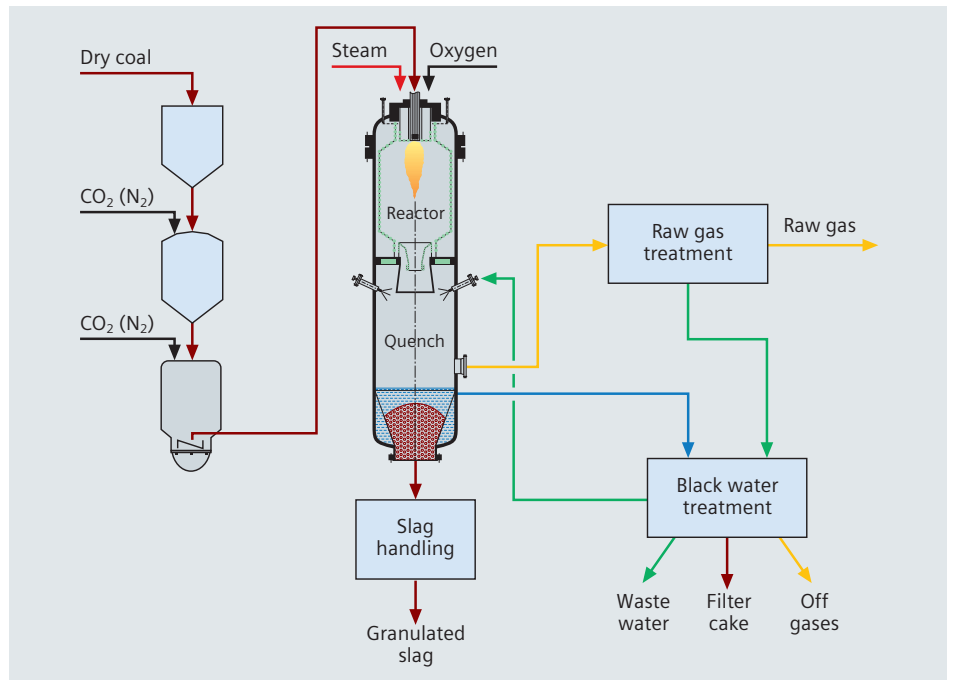
The Siemens Fuel Gasifier is the heart of the Gasifier Island. Process steps like the dry feed system, slag handling system, the raw gas treatment and the black water treatment complement the gasifier island. Siemens offers design and basic engineering of the complete gasifier island process. The process layout ensures efficient design, optimized handling of by-streams and water usage and minimum interfaces to downstream processes and utilities.

Raw Gas Treatment

Downstream of the quench section, the syngas passes to a raw gas treatment section with venturi scrubbers and a partial condenser. The system removes fine particles, halogens and alkalines from the raw gas flow. The raw syngas leaving the gasifier island is essentially free of particulates.

Black Water Treatment

The liquid effluents of the quench zone, water from the slag discharge units and scrubbing water from the raw gas treatment contain fine particulate matter, soot, salts and volatile heavy metal sulfides. Water from the black water treatment system is recycled back to the quench section.





Solution for many applications

Siemens gasifiers are equally well suited for power generation in Integrated Gasification Combined Cycle (IGCC) as well as production of chemicals, and synthetic fuels. Resulting products may be used in refineries, for iron or fertilizer production, transportation and in many other applications.

Most of the downstream processes require a fixed H_2/CO ratio which is adjusted in a CO shift reactor downstream of the gasifier. In the reactor, the equilibrium of the CO shift reaction $CO + H_2O \rightleftharpoons CO_2 + H_2$ is influenced by adding water to increase the hydrogen content of the syngas. The raw gas from the quench is already saturated with water and little or no additional steam injection is needed for the shift reaction.

Gas conditioning complexity depends on the requirements of the downstream process. For desulfurization and CO_2 removal, standard chemical or physical absorption processes can be applied. Elemental sulfur can be removed and sold as a marketable by-product. For sequestration, CO_2 is compressed and transported to underground storage sites or used for Enhanced Oil Recovery.

IGCC

Integrated Gasification Combined Cycle (IGCC) combines modern gasification with advanced gas turbine and steam turbine power generation technology. The concept of an IGCC power plant incorporates a gasifier producing raw gas which is cleaned of pollutants and burned in the combustion chamber of the gas turbine-generator for power generation. Matching mass and heat flow in an IGCC system offers further potential to optimize overall plant efficiency and economics.

IGCC emission levels can be in compliance with the most stringent emission regulations. It offers performance which is comparable to state-of-the-art supercritical steam plants. Application of CO_2 removal in IGCC's is straightforward with commercially available technology and offers flexible CO_2 emission reduction to very low levels.



Besides gasification, Siemens can provide entire power islands, air compressor technology, water treatment solutions and plant instrumentation and controls. Siemens is able to offer customized IGCC solutions – everything from an equipment-only solution to providing the complete IGCC Power Island on a turnkey basis.

References

SVZ, Waste Recycle Center “Schwarze Pumpe”	
Location:	Schwarze Pumpe, Germany
Commercial operation:	1984
Technical data	
Capacity:	200 MW _{th} (25 bar)
Type of reactor:	Entrained-flow, cooling screen
Type of quench system:	Full quench
Feedstock:	Lignite (1984-89) Natural gas (1989, 1990) Liquid waste, tars & oils (1990 – present)
Products / by-products:	Syngas for methanol and power production / sulfur, slag

SOKOLOVSKÁ UHELNÁ, A.S., Autothermal Oil Conversion Plant	
Location:	Vřesová, Czech Republic
Commissioning:	2008
Technical data	
Capacity:	175 MW _{th} (28 bar)
Type of reactor:	Entrained-flow, refractory-lined
Type of quench system:	Full quench
Feedstock:	Tar and liquid by-products of 26 fixed-bed gasifiers
Products / by-products:	Syngas for power production / slag, soot cake

Shenhua Ningxia Coal Industry Group	
Location:	Ningxia, China
Commissioning:	2009
Technical data	
Capacity:	5x 500 MW _{th} (40 bar)
Type of reactor:	Entrained-flow, cooling screen
Type of quench system:	Full quench
Feedstock:	Hard coal
Product:	Syngas for chemical production

Shanxi Lanhua Coal Chemical Corporation	
Location:	Jincheng, China
Commissioning:	2010
Technical data	
Capacity:	2x 500 MW _{th} (40 bar)
Type of reactor:	Entrained-flow, cooling screen
Type of quench system:	Full quench
Feedstock:	Anthracite
Product:	Syngas for ammonia and urea production

Secure Energy	
Location:	Decatur, Illinois, USA
Commissioning:	2010
Technical data	
Capacity:	2x 500 MW _{th} (40 bar)
Type of reactor:	Entrained-flow, cooling screen
Type of quench system:	Full quench
Feedstock:	Bituminous coal
Product:	Syngas for synthetic natural gas production

Siemens Gasification Test Center

With the Gasification Test Center in Freiberg, Germany, Siemens owns one of the most comprehensive gasification test facilities in the world. More than 60 different fuels have been tested so far, which gives Siemens a rich body of experience.

The centerpiece of the Siemens Gasification Test Center is a 5 MW_{th} gasification reactor with operating pressures up to 26 bar. The test gasifier is complemented by a range of feedstock preparation systems and related gas cleaning process units. Further equipment for coal and slag analysis (e.g. fluidization behavior and viscosity) is available.

With this equipment, a broad range of test conditions can be simulated. For gasification-based projects, for instance, it can be used to test how to:

- Determine detailed analytical data of feedstock and gasification products
- Optimize feedstock preparation to maximize efficiency and carbon conversion rate
- Determine the optimum gasification process conditions
- Gain valuable information about the expected products and environmental performance.

Dry feeding test rig

The Siemens Gasification Test Center furthermore provides a test rig for high-pressure coal feeding. This test rig consists of a fully equipped dry feeding system and can be used to find optimized feeding solutions. In particular, it allows the following aspects to be explored:

- Investigation of fluidization behavior under elevated pressure conditions
- Comparison of different coal density and velocity measurement systems
- Investigation of different feeding gases for solid feeding
- Test of alternative dry feeding systems

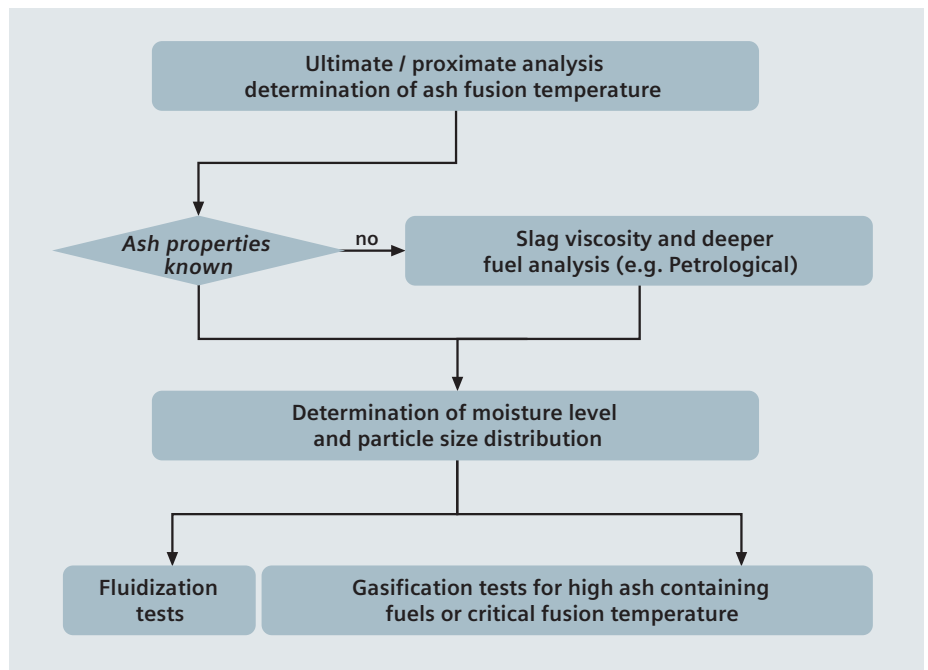


Figure: Testing procedure

Siemens Fuel Gasification Technology GmbH	
Location:	Freiberg, Germany
Commercial operation:	1996
Technical data	
Capacity:	3-5 MW _{th}
Type of reactor:	Entrained-flow, cooling screen, retrofittable with refractories, dry or liquid feeding possible
Feedstock:	More than 60 different fuels tested so far

With our test center and extensive knowledge and experience in gasification technology, Siemens offers an unparalleled level of solutions that help the customers achieve compatibility and profitability faster and easier.



Scope of supply and services

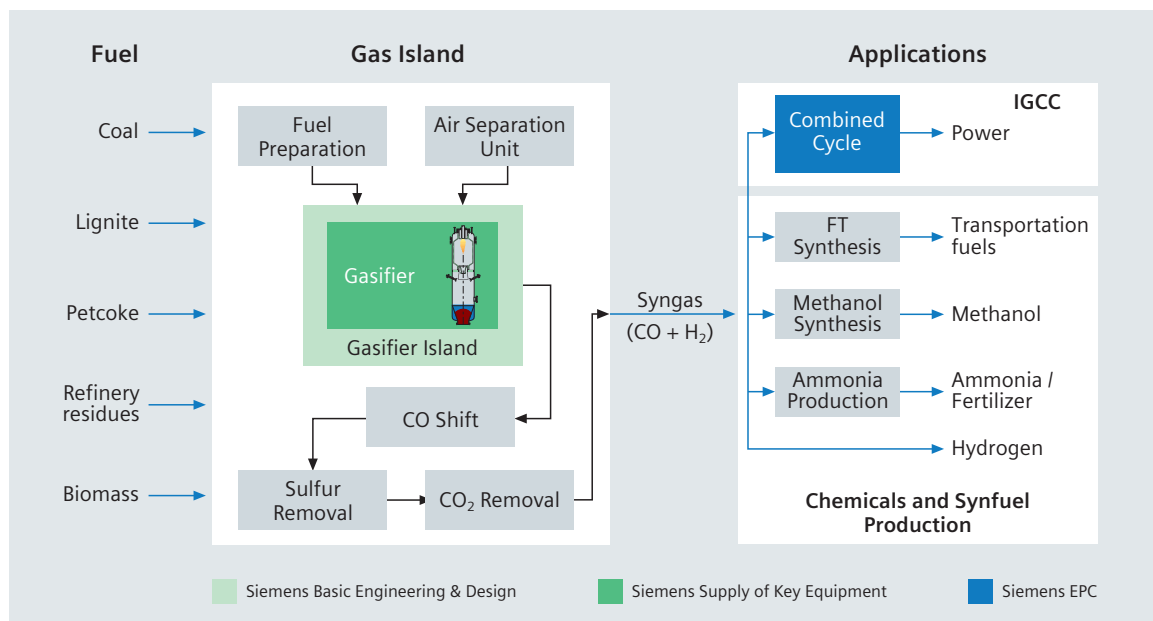
Siemens is entirely committed to delivering tailored technology that is more reliable, more efficient, more competitive, and easier to maintain. The solutions we offer push the highest limits of efficiency and reliability. According to the customer's needs, Siemens provides all services from engineering the Gasifier Island to key equipment and project execution.

Siemens scope of supply includes:

- Licensing of the Siemens Fuel Gasification technology
- Process Design Package (PDP) and Basic Engineering Design Package (BEDP) for the Gasifier Island
- Supply of key equipment like reactor, cooling screen, burner, and more
- Feasibility and FEED studies for the Gasifier Island

- Gasification tests
- Engineering services and Technical Field Assistance

As part of our commitment to being customer focused, we provide an established powerful and responsive service network. We are available for you worldwide when and where you need us – for technical field assistance, parts, or operations and maintenance services.



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