From solid fuels to substitute natural gas (SNG) using TREMP™

RESEARCH | TECHNOLOGY | CATALYSTS

HALDOR TOPSØE

CATALYSING YOUR BUSINESS

Topsøe Recycle Energy-efficient Methanation Process

Introduction

Natural gas is a clean, environmentally friendly energy source and is expected to constitute an increasingly greater part of world energy consumption over the next decades. Natural gas reserves are sufficient to meet the forecasted demand. However, natural gas often has to be transported over long distances from gas well to the consumer.

This logistic challenge may be solved by transporting the natural gas in the liquid form (LNG). However such liquification and transport are associated with considerable cost and use of energy.

Furthermore, natural gas is a very price-volatile energy source, making it financially attractive to produce natural gas from coal, petcoke, biomass or waste.

The obvious advantages with a stable, secure domestic energy source have in many countries further strengthened the interest in coal, petcoke, biomass or waste as energy sources. Converting these raw materials into a gas that can be used in an existing natural gas network solves the distribution aspect of using solid fuels as a general source of energy.

Haldor Topsøe offers a unique and cost-efficient technology which can produce Substitute Natural Gas (SNG) from cheap carbonaceous feedstocks. SNG is rich in methane and can be used interchangeably with natural gas and distributed by the same means.

The conversion of coal into SNG takes place in several steps as illustrated in figure 1.

- gasification of coal, petcoke, biomass or waste to produce a gas rich in hydrogen and carbon monoxide
- shift conversion to adjust the ratio between hydrogen and carbon monoxide
- acid gas removal, where carbon dioxide and hydrogen sulphide are removed in a washing process
- methanation to convert carbon oxides and hydrogen to methane (SNG) followed by drying and possibly compression of the product SNG to pipeline conditions
- production of oxygen for the gasification process in an Air Separation Unit
- recovery of sulphur from the acid gas removal unit, for example by converting the sulphur to concentrated sulphuric acid in a Topsøe Wet Sulphuric Acid (WSA) unit

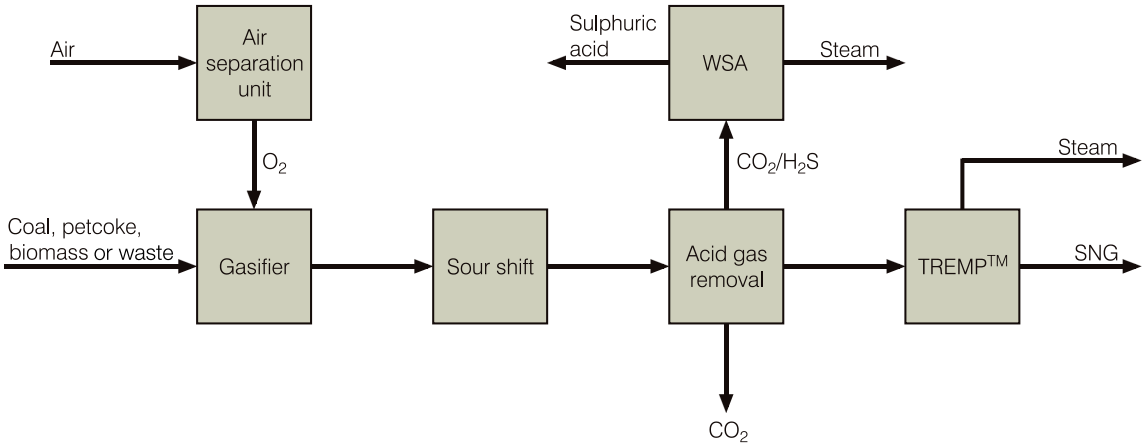

Figure 1: Gasification process – from coal, petcoke, waste or biomass to SNG.

What is methanation?

Methanation is the reaction of carbon oxides with hydrogen to form methane according to the following equations:

$$CO + 3H_2 \Leftrightarrow CH_4 + H_2O$$
$$CO_2 + 4H_2 \Leftrightarrow CH_4 + 2H_2O$$

Both reactions are highly exothermic, releasing large amounts of reaction heat. Efficient recovery of the heat of reaction, which amounts to about 20% of the heating value of the synthesis gas, is essential for any industrial methanation technology.

Basically:

Syngas ⇔ SNG + heat
Energy: 100% ⇔ 80% + 20%

What is TREMP™?

TREMP™ stands for

Topsøe Recycle Energy-efficient Methanation Process.

The TREMP™ technology addresses the essential question of heat recovery most efficiently by recovering the heat as high pressure superheated steam. This concept requires that the reaction heat is recovered at a high temperature.

TREMP™ is based on the unique Topsøe MCR methanation catalyst family, which has high and stable activity in a wide temperature range – from 250ºC to 700ºC (475-1,300°F). In short, the properties of MCR offer the following advantages:

- reaction heat is recovered as high pressure superheated steam for use directly in a steam turbine
- a large temperature rise over Topsøe MCR catalyst results in a very low recycle ratio with corresponding energy savings and reduced equipment cost

Topsøe TREMP™ units are tailor-made, resulting in an optimised and cost-effective design. The technology is based on in-house R&D, catalyst development, and thermodynamics as well as detailed mechanical know-how.

Product

The TREMP™ technology produces a natural gas compatible with pipeline specifications, ensuring easy distribution of the product. A typical specification is given in table 1.

CH_4, mole-%	94-98
CO_2, mole-%	0.2-2
H_2, mole-%	0.05-2
CO, mole-%	<100 ppm
N_2 + Ar, mole-%	2-3
HHV, KJ/Nm^3	37,380-38,370
HHV, Btu/scf	950-975

Table 1: Typical specification of SNG produced by the TREMP™ technology.

High pressure superheated steam

The Topsøe TREMP™ technology ensures a very effective heat recovery. Up to 85% of the released heat from the methanation reactions is recovered as high pressure superheated steam.

Typical superheated steam properties:
100 bar g/540°C (1,450 psig/1,000°F)

Typical steam production is about 3.0-3.5 kg/Nm^3 (0.18-0.21 lbs/scf) SNG and only a minor amount of the energy is removed by water cooling as illustrated in figure 2.

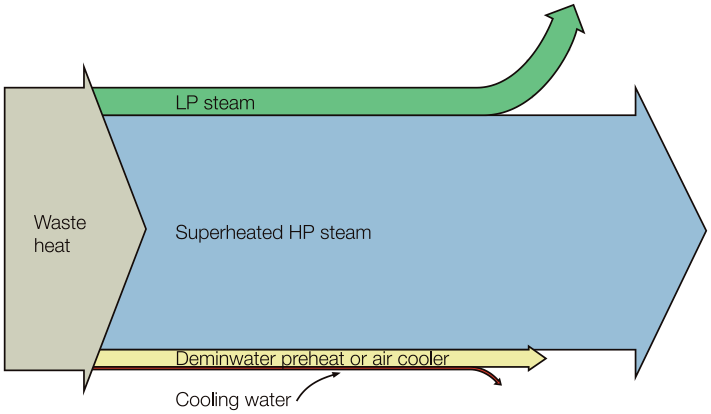

Figure 2: Heat recovery in TREMP™.

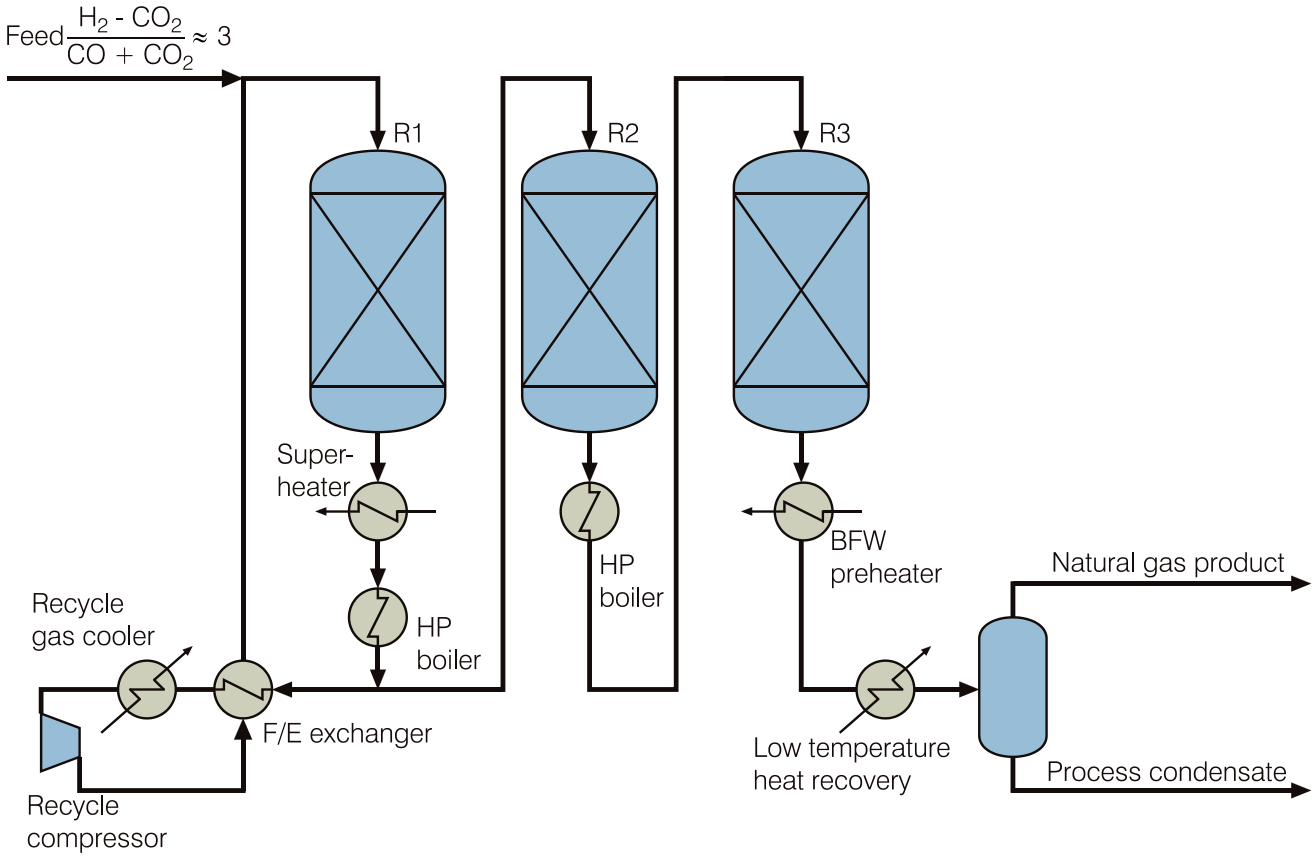

Figure 3: Example of the Topsøe TREMP™ technology.

TREMP™ process description

The process steps upstream of the methanation unit are designed to provide a near stoichiometric ratio of hydrogen to carbon oxides in the gas according to the methanation reactions.

The reactions in TREMP™ take place in adiabatic fixed bed reactors. The heat of the reaction results in a high temperature increase, and recycle is used to control the temperature rise in the first methanation reactor.

In order to minimise energy consumption, our TREMP™ process is optimised for minimum recycle. This is possible due to the unique high-temperature stability of the MCR catalyst family.

The exit gas from the first reactor is cooled by production of superheated high pressure steam. The gas then enters the subsequent methanation stages, as shown in figure 3. The number of reactors and the configuration of the process depend on the specific application. Based on continuous dialogue with our clients, Topsøe will suggest the optimal layout for each project.

The high temperature methanation catalyst – MCR

As a company providing both catalysts and technology developed in-house, Haldor Topsøe is in a unique position to optimise the process. The development of the high temperature methanation catalyst MCR allows for favourable technology features, such as high energy efficiency and low pressure drop. The long term stability has been demonstrated through more than 40,000 hours of operation.

The low temperature methanation catalyst – PK-7R

The superior activity and stability of the PK-7R catalyst used in the "clean-up" reactor enables operating at low temperatures which ensure maximum conversion of carbon oxides. PK-7R has a very high thermal stability and can operate at temperatures as high as 450°C (840°F). With its ring shape, the PK-7R catalyst achieves a 50% reduction in pressure drop relative to the conventional spherical or cylindrical shaped methanation catalysts.

Practical experience with TREMP™

The operating experience of the TREMP™ technology dates back to the late 70's, and substantial process demonstrations have taken place ensuring that the technology is ready for large-scale applications.

The process has been demonstrated in semi-commercial scale in various plants producing between 200 and 2,000 Nm^3/h (7.5 and 75 MSCFH) of SNG product under realistic industrial conditions (which means that reactor diameter is the only scale-up parameter). The MCR catalyst has also been tested independently in Topsøe pilot facilities as well as in a pilot plant of Union Kraftstoff Wesseling (UKW), Germany. The longest run at the pilot facilities on the same catalyst charge lasted 10,000 hours and proved MCR as a very stable catalyst.

Conclusions

Haldor Topsøe offers the TREMP™ methanation technology including the proprietary catalyst family MCR which is able to operate in the temperature range from 250ºC to well above 700ºC (475-1,300°F). This allows us to offer our TREMP™ technology with the unique feature of recovering the reaction heat at a high temperature, making the TREMP™ technology the most efficient SNG technology.

The thousands of hours of demonstrations provide a solid basis for design of industrial plants optimised for each specific feed gas.

The TREMP™ process offers state-of-the-art technology for commercial operation. Process and detailed engineering will be supplied with guaranteed performance.

In conclusion, the Topsøe TREMP™ technology is characterised by:

- high energy efficiency
- production of high pressure superheated steam
- low investments
- production of a natural gas compatible with pipeline specifications

Figure 4: The TREMP™ semi-commercial reactor used for production of 200 Nm^3/h of SNG product.

Your technology partner

Since 1940, Topsøe has specialised in heterogeneous catalysis, process development and engineering. A continuous focus on research and development has ensured that Topsøe's technologies and catalysts remain second to none. The many different types of process plants designed by Topsøe promote synergy and give our clients the benefit of a wide-reaching experience.

Topsøe's product portfolio extends from catalyst production, licensing and engineering of proprietary catalytic processing units to in-house process development, project management and technical service. Proprietary know-how of all these fields ensures clients a competent business partner.

The Topsøe business portfolio

The firm commitment to catalysis and process technology has strengthened Topsøe's position in a wide range of additional business areas: Development and supply of catalysts and technologies for the production of ammonia, methanol and other petrochemicals, for gas conversion, oil refining and for emission control for the power and automotive industry.

Working with Topsøe, clients will benefit not only from our long-term knowledge of syngas related processes, but also from a broad portfolio of other technologies and catalysts:

- hydroprocessing and hydrogen production in the refining and petrochemical industry
- ammonia, methanol, DME, substitute natural gas (SNG) and coal to liquid (CTL) in coal based industries
- recovery of sulphur from off-gases and production of commercial-grade concentrated sulphuric acid with Topsøe's WSA technology

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