Shell Coal Gasification Process for Power and Hydrogen/Chemicals

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Shell Coal Gasification Process for Power and Hydrogen/Chemicals

- Introduction, Progress
- Features, Benefits
- US Case Study
  - Basis Of Design
  - Results
- Conclusions
Shell Gasification Optional Products

Coal
Lignite
Petroleum Coke
Biomass
Oil/Resid
Gas
Orimulsion

Shell (Coal) Gasification Process

Syngas

CC_Cogen Power Generation

Electricity
Steam

Chemical feedstock

Ammonia
Methanol
Hydrogen
other chemicals

Conditioning/distribution

Town gas

Liquefaction

Transportation Fuel
From Deer Park (US) to Buggenum (NL)

1987-1995
250-400 tpd

1993 – Present
2000 tpd coal
253 MW_e Demo Plant
New SGP projects:
- Agip Sannazzaro Refinery
- Opti, Canada
- Rafineria Gdanska, Poland

New SCGP projects:
- 12 projects in China
- 1 project USA (WMPI)
Yueyang Sinopec and Shell Coal Gasification Co Ltd
2,000 t/d plant to supply a fertiliser plant.* 2001

Hubei Shuanghuan Chemical Group Co Ltd
900 t/d plant to supply a fertiliser plant. 2001

Liuzhou Chemical Industry Co Ltd
1,200 t/d plant to supply fertiliser plant. 2001

Sinopec Hubei Chemical Fertiliser Co
2,000 t/d plant to supply a fertiliser plant. 2003

Sinopec Anqing Chemical Fertiliser Co
2,000 t/d plant to supply a fertiliser plant. 2003

Yunnan Tianan Chemical Co Ltd
2,700 t/d plant to supply a fertiliser plant. 2003

Yunnan Zhanhua Co Ltd
2,700 t/d plant to supply a fertiliser plant. 2003

Dahua Group Ltd
1,100 t/d plant to supply methanol plant. 2004

Yongcheng Coal and Power Group
2,150 t/d plant to supply a methanol plant. 2004

Shenhua Coal Liquefaction Corporation
2x2,250 t/d plant to supply H2 for coal liq. 2004

Zhongyuan Dahua Group
2,150 t/d plant to supply methanol plant. 2004

Kaixiang Group
1,000 t/d plant to supply methanol plant. 2004

* Shell-Sinopec 50/50 joint venture
SCGP Reactor
Syngas Cooler
Assembly
SCGP Key Benefits since Buggenum (NUON)

Proven
- Reactor Membrane wall expected life-times > 25 yrs
- Burner life-times > 20,000 hrs
- Reactor-Syngas Cooler ~40% cheaper (international supply)
- Steam system simplified (headers, pipe spec, materials optimized)
- Water-cooled skirt Reactor
- Slag crusher
- Wider procurement options equipment
- Reactor-Syngas Cooler train up to 5000 tpd
- Unplanned outages < 4% (scheduled maintenance project specific)

New Projects
SCGP IGCC USA Case Study – Block Flow

Air Separation Unit

1-2 string combinations

HPO2
HPN2
Air
MPN2
Net Elec.
400 MW
550 MW
800 MW

Syngas Manufacturing Process Plant

Combined Cycle Power Plant

Pitts#8
PRB
PRB/C

HPS
MPS
BFW
Cond
Syngas
SCGP IGCC USA Study – Economic Premises (NPV)

- Project location factor HOLLAND Michigan USA (ISO conditions)
- Project life 25 years, 7008 h/a (80% full load IGCC)
- O&M 50 $/kW\textsubscript{e} net/a + 0.002 $/kWh
- Depreciation 15 years, 90% of investment
- Debt/equity ratio = 80/20; discount rate 5.5%, tax 38.2% (Harvard)
- Inflation/escalation rate 4% (coal no inflation)
- EPC contractor soft costs typical ratio’s, no Owners Costs
- Electricity price (year 0) 40 $/MWh
- Fuel price (year 0) 0.6-1-1.24 $/MMBtu (Cokes-PRB, PRB, P#8)
SCGP IGCC USA Study – Economics Steam Pressure

Specific Investment for 800 MW_e IGCC

Simpler Steam System reduces $/kW_e 5-6%

- IGCC_eff 46.5 %HHV
- IGCC_eff 45 %HHV

Powder River Basin
SCGP IGCC USA Study – Economy Of Scale

Specific IGCC Investment Powder River Basin

$/kW_e

CCPP
Gasification
ASU
AGR-SRU
Syngas MF H2O
Syngas MF gen

Power
Coal

1-1 IGCC 1-2 IGCC 2-2 IGCC 2-2 IGCC
418 418 572 572 837 837
2959 2959 4097 4097 5918 5918

2-2 => 1-2 IGCC reduces $/kW_e 12%
SCGP IGCC USA Study – Economics Coals/Pet Coke

SCGP insensitive to coal types for $/kW_e; max. 4% bituminous vs sub-bituminous types

SCGP IGCC economics improve as a result!
Comparison SCGP vs US Literature [Pittsburgh#8]

Ref. Harvard Report/EPRI Summary Cases ‘03:
- 2* Syngas Manufacturing Blocks (2R)
- 2* 7FA Power Block 550 MW_e
- Owners Costs/Contingency ~4% included

Shell New Comparison [US Paper 2004]:
- 1* or 2* Syngas MF Blocks (1R or 2R)
- 2* W501F Power Block 550 MW_e
- Shell study ‘04 without OC/Contingency
- BOP robust (Cooling Towers, FO back-up)
Conclusions SCGP based IGCC

- IGCC costs can be lowered to 1000-1100 $/kW_e in 2 steps:
  - By simplifying steam system (SGC pressure 50-77 bar)
  - By scaling up SCGP with SMPP units > 4000 tpd
- HHV efficiencies 44-45% including 1.5% drop for 125->50 bar SGC
- SCGP $/kW_e insensitive to Sub-bit coals (~3-4% HHV)
- Petcoke coal mixes can be economic
- SCGP systems do not need spare reactor due to reliable design