SYSTEM INTEGRATION AND WATER BALANCE ISSUES IN POLYGENERATION GASIFICATION PLANTS

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**SK: TOTAL SOLUTIONS PROVIDER**

90 Affiliated Companies, Over 60,000 Employees, Sales US$ 106.3 Billion

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### Energy & Chemicals

- **(32 companies)**
  - E&P, Refinery, LPG & Gas Supply, Power, Chemicals & Petrochemicals, Life Science

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### Telecommunications

- **(27 companies)**
  - Mobile Network Operator, U-City, Satellite Communication, Internet TV

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### Trading & Services

- **(26 companies)**
  - Trading, Logistics, Engineering & Construction, Hotel, Securities

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### Facts about the SK Group

<table>
<thead>
<tr>
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<th>3(^{rd}) Largest in Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the total asset size of domestic enterprises</td>
<td>9.8%</td>
</tr>
<tr>
<td>SK's share of Korean GDP</td>
<td>SK's share of total Korean exports</td>
</tr>
<tr>
<td>In Oil &amp; Gas Sector in Korea</td>
<td>First</td>
</tr>
<tr>
<td>In Telecommunication Sector in Korea</td>
<td>57th</td>
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</tbody>
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**New SK member in 2012**

- **2\(^{nd}\)**
  - The world's second-largest memory-chip maker
  - $9 Billion sales in 2011
GASIFICATION

SYSTEM INTEGRATION AND WATER BALANCE ISSUES ARE SOME OF THE MOST IMPORTANT PROBLEMS THAT A GASIFICATION PROJECT INTEGRATOR HAS TO SOLVE OVER THE COURSE OF THE PROJECT.

- SYSTEM INTEGRATION: DEFINED AS THE PROCESS OF BRINGING TOGETHER THE COMPONENT SUBSYSTEMS INTO ONE, AND ENSURING THAT THE SUBSYSTEMS FUNCTION TOGETHER.
  - CAN ACHIEVE HIGHER EFFICIENCY, LOWER EMISSIONS, LOWER OPERATING COST
  - POTENTIAL FOR INCREASED COMPLEXITY & HIGHER CAPITAL COST

- WATER BALANCE:
  - CRITICAL TO PROPER PLANT OPERATION
  - WATER ISSUES DURING STARTUP, NORMAL OPERATION, AND ABNORMAL OPERATION
GASIFICATION PLANTS HAVE SEVERAL OPPORTUNITIES FOR SYSTEM INTEGRATION, E.G.:

- SYSTEM INTEGRATION IN BETWEEN THE ASU, PLANT UTILITIES, AND IGCC GAS TURBINES
- HEAT RECOVERY FROM SYNGAS COOLING AND WATER-GAS SHIFT REACTION
- OFF GAS FROM PROCESS UNITS (HYDROGEN PSA, METHANOL, AMMONIA, ETC.) TO FUEL GAS/AUX BOILER/POWER GENERATION
SYSTEM INTEGRATION BETWEEN ASU/GAS TURBINE/UTILITIES

- Feeding Extraction Air from IGCC Gas Turbine to Air Separation Unit
- Nitrogen (DGAN) from Air Separation Unit to IGCC Gas Turbine as Diluent
- Use of Dry Air from ASU as Plant Air/Instrument Air
- Use of Gan (Gaseous Nitrogen) from ASU as HP and LP Utility Nitrogen
HEAT RECOVERY FROM SYNGAS

BEST PRACTICES FOR GASIFICATION HEAT RECOVERY

HEAT RECOVERY FROM HIGH TEMPERATURE SYNGAS (>350°F): RADIANT SYNGAS COOLERS, WATER-GAS SHIFT

- STEAM GENERATION IS THE PREFERRED OPTION (HOWEVER, ATTEMPTING TO MAXIMIZE STEAM GENERATION CAN CAUSE ISSUES)
- BFW ECONOMIZERS ARE A SECONDARY OPTION
- IGCC SYNGAS/NITROGEN SATURATION - WHERE APPLICABLE
- AGR STRIPPER REBOILER SERVICE (SUITABILITY DEPENDS ON SOLVENT PROPERTIES)

STEAM GENERATION

Diagram:
- High Temp Sour Shift Reactor
- Low Temp Sour Shift Reactor
- Heat Integration
- Production
- Shifted Syngas
HEAT RECOVERY FROM SYNGAS

HEAT RECOVERY FROM LOW TEMPERATURE SYNGAS:
- LP STEAM GENERATION - PREFERRED OPTION
- BFW/CONDENSATE HEATING - SECOND OPTION
- COOLING WATER, AIR COOLERS - LAST RESORT FOR TRIM COOLING
HEAT RECOVERY FROM SYNGAS

MOST COMMON RISK FOR SYNGAS HEAT RECOVERY: SYNGAS LEAK INTO LOW PRESSURE SYSTEM (TUBE LEAKS IN THE HEAT EXCHANGERS)

SYNGAS LEAK MITIGATION:
  • HEAT EXCHANGER DESIGN THAT REDUCES TUBE LEAKS
  • SYNGAS LEAK DETECTION SYSTEMS

MITIGATION INCREASES CAPITAL COST
# SYSTEM INTEGRATION
## FEED CASE STUDY

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<th>ITEM</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td><strong>PROJECT NAME</strong></td>
<td>Lake Charles Clean Energy (LCCE)</td>
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<td><strong>CLIENT</strong></td>
<td>Leucadia Energy/Leucadia National</td>
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<tr>
<td><strong>LOCATION</strong></td>
<td>Lake Charles, LA</td>
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| **FACILITY CAPACITY**       | **Feedstock**: 7000 TPD Petcoke (Koch Carbon, LLC)  
                          | **Products**: Methanol: >1 Million TPY (BP); Hydrogen: >100 MMSCFD (Air Products); Carbon Dioxide: Approx. 4.5 Million TPY (Denbury Resources)                                                                 |
| **GASIFICATION**            | GE                                                                                                                                                                                        |
| **AIR SEPARATION UNIT**     | Air Products                                                                                                                                                                              |
| **METHANOL**                | Haldor Topsoe                                                                                                                                                                             |
| **ACID GAS REMOVAL**        | Air Liquide/Lurgi Rectisol                                                                                                                                                                 |
ELECTRIC POWER IMPORT REDUCED BY MORE THAN 50%!
WATER BALANCE ISSUES: STARTUP, NORMAL OPERATION, ABNORMAL OPERATION, UPSETS

- NEED TO CONTROL AMOUNT OF WATER PRODUCED DURING STARTUP SYNGAS FLARING
- NORMAL OPERATION: GREY WATER BLOW-DOWN TO ZERO LIQUID DISCHARGE IS REQUIRED FOR CONTROLLING THE CHLORIDES/FORMATES CONCENTRATION TO MITIGATE GREY WATER PIPING CORROSION; NEED TO MINIMIZE BLOWDOWN VOLUME
- ABNORMAL OPERATION/UPSETS: CONTAMINATED STORMWATER FROM THE GASIFICATION AREA NEEDS TO BE SEGREGATED AND WORKED-OFF INTO THE PROCESS
**WATER CONSUMPTION**

- **CONSUMPTION IS MINIMIZED BY RECYCLING GASIFICATION GREY WATER**
- **STEAM BLOW-DOWN AND OTHER LOW-TDS WATER STREAMS ARE SENT TO THE COOLING TOWERS**
- **THE ONLY FACILITY WATER DISCHARGED TO THE OUTFALL ARE COOLING TOWER BLOW-DOWN AND RAW WATER/MAKE-UP WATER TREATMENT WASTE STREAMS**
WATER BALANCE

- COOLING TOWERS ARE THE LARGEST CONSUMERS OF WATER (EVAPORATION AND BLOW-DOWN)
- THE NEXT LARGEST CONSUMER IS THE GASIFICATION PROCESS

Plant Water Consumption

<table>
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<tr>
<th>Component</th>
<th>Water Consumption (%)</th>
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<tr>
<td>Cooling Towers</td>
<td>81</td>
</tr>
<tr>
<td>Gasification Makeup</td>
<td>13</td>
</tr>
<tr>
<td>Raw Water Treatment</td>
<td>5</td>
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<tr>
<td>Other Process Makeup</td>
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</table>
WATER BALANCE

LOW ENERGY
ZERO LIQUID DISCHARGE SYSTEM

Fuel Gas

Hot Side Cooling Tower Circulating Water

Cooled Circulating Water to Cooling Tower Basin

Gasification Grey Water Blowdown

BIOLOGICAL TREATMENT

ATMOSPHERIC EVAPORATION

THERMAL SOLIDS DRYING

EVAPORATION

BRINE SOLIDS TO CLASSIFIED LANDFILL

NON-HAZARDOUS WASTE SOLIDS
SUMMARY

• SYSTEM INTEGRATION
  • MANY OPPORTUNITIES FOR SYSTEM INTEGRATION IN A GASIFICATION PLANT
  • CAN RESULT IN INCREASED COMPLEXITY & HIGHER CAPITAL COST
  • CAN BE WORTHWHILE FOR ACHIEVING HIGHER EFFICIENCY, LOWER EMISSIONS, LOWER OPERATING COST, AS SHOWN BY THE LEUCADIA LCCE CASE STUDY

• WATER BALANCE
  • MAINTAINING A GASIFICATION PLANT’S WATER BALANCE IS A MAIN PRIORITY FOR BOTH NORMAL AND ABNORMAL OPERATION
  • NEED TO CONTROL AMOUNT OF WATER PRODUCED DURING STARTUP SYNGAS FLARING
  • CONTAMINATED STORMWATER FROM THE GASIFICATION AREA NEEDS TO BE SEGREGATED AND WORKED-OFF INTO THE PROCESS
  • NEW LOW ENERGY ZERO LIQUID DISCHARGE SYSTEM: REDUCES POWER AND STEAM REQUIREMENTS
THANK YOU!

QUESTIONS OR COMMENTS?

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