THE PUERTOLLANO IGCC PLANT: STATUS UPDATE

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ABSTRACT

The Puertollano IGCC plant accomplished the first gasifier firing by the end of December 1997 and the first gas turbine coal gas operation in March 1998. Up-to-date, an extensive combined cycle operation with natural gas, exhaustive functional tests for the air separation unit and commissioning and test of the gasification systems have provided the grounds for the demonstration of the IGCC technology.

The plant commissioning was arranged, since the project conception, in two steps to profit from an earlier natural gas operation of the combined cycle ahead of burning syngas generated in the gasification island. The high degree of integration of the major plant blocks, as result of the selected design concept, requires integrated and stable operation of the combined cycle and the air separation unit, which has impacted on the timely completion of the gasification start-up and tests. The facts below summarizes the plant status.

- Since the completion of the combined cycle 100 hour test in late 1996, the plant production has exceeded the 1.4 million MWh.
- Integrated operation of combined cycle, air separation unit and gasification island has been accomplished. The time gap between the first gasifier firing and the first gas turbine coal gas operation was three months.
- The scope and extent of changes during the gasification commissioning have not been mostly related to major modifications.
- A full assessment of required improvements to reach steady IGCC operation has been conducted.
The objectives during 1998 are those required to have the plant ready for Acceptance Tests. These will be preceded by the coal gas combustion tests (due to start in early September 1998) that shall enable steady syngas operation, sulphur recovery plant operation, an 100 hour continuous gasifier operation as well as integrated control tuning.

INTRODUCTION

ELCOGAS is a consortium of eight European utilities and three technology suppliers that launched in 1992 the Puertollano project to demonstrate the commercial feasibility of the Integrated Gasification with Combined Cycle (IGCC) technology. The 335 MWe (ISO) demonstration plant have been designed to use a 50/50 mixture of high ash local coal and petroleum coke from a nearby refinery. The project was selected as Target Project by the European Commission and awarded funding by the THERMIE program focused on the need to take short-term actions to assure reliable clean coal technology for the future power generation.

The Puertollano IGCC project has been driven by the demand of energy efficient, environmentally friendly and cost effective coal generation technologies. The plant design innovative features focused on two main targets: improved efficiency (45% net, ISO conditions) and reduced emissions. The design concept is arranged at the maximum integration level (air and nitrogen streams) and large capacity components (2600 t/day gasifier and 200 MW gas turbine) were selected.

PROJECT BACKGROUND

The ELCOGAS project in the clean combustion technologies context

The Puertollano IGCC project originated as an international technological initiative in response to the concerns raised in Spain and the European Union (EU) on the following issues:

- The need to develop efficient coal generation alternatives from an energy, environmental and mid-term economic point of view. Among them, IGCC.
- The increasingly more stringent environmental regulation to reduce emissions in thermal power stations. The EU issued the Large Combustion Plant Directive in the late 80’s.
- The creation of the THERMIE program aimed at promoting and encouraging clean coal technologies while decreasing the energy dependency on natural gas in the EU.
- The Puertollano IGCC project was included within the Spanish National Energy Plant (1991-2000) as part of the additional capacity to be installed with acknowledgement of the outstanding environmental performance against higher investment cost.

The Spanish electricity regulatory framework

The Spanish utilities and the Ministry of Industry and Energy signed in December 1996 a new regulation for the electricity system in Spain, namely The Protocol. The existing
Stable Legal Framework is replaced by a market driven system that ensures competition and splits the generation and distribution activities beyond 2001.

*The Protocol* establishes that a System Operator will be responsible for dispatching and a Market Operator for settlement and payment to generators. The generation facilities will operate on the basis of their bids to the pool. The market liberalization is provided by allowing customers with consumption higher than certain limits to gradually choose their source of supply.

The evolution towards a competitive market is intended to be safeguarded by a ten-year transition period from 1998 to 2007 that will include:

- Over 20 GWh/year consumers can choose source of supply in 1998. Others will follow.
- Unique tariff prices nation-wide up to 2001.
- Payment to generators to account, at some extent, for investments made under the Stable Legal Framework (Cost of Transition to the Competition).

ELCOGAS financing and operation scheme was laid out under the 10-year Spanish Energy Plan (1991-2000) as part of the existing regulatory framework. Ongoing negotiations will define the treatment of the Puertollano Project during the transition period.
**TECHNICAL DATA**

**IGCC Performance at 100%, T = 15ºC**

**DESIGN FUEL**
- 50% coke / 50% coal
- Mass Flow: 23500/23505 t/24h

**POWER OUTPUT**
- Gas Turbine: 182.3 MW
- Steam Turbine: 135.4 MW
- Total Gross: 317.7 MW

**EFFICIENCY**
- Gross (LHV): 47.12%
COMMISSIONING AND START-UP IN FIGURES

In the following, the most relevant figures corresponding to the commissioning phase through June are reported.

- Number of gasifier runs: 29
- Hours with gasifier operation: 200
- Longest gasifier run in hours: 25
- Number of gas turbine syngas runs: 5
- Hours with gas turbine on syngas: 1.7
- Net production on coal/coke operation in MWh: 6300

FIRST RESULTS

On December 19, 1997 the first raw gas was produced in the PRENFLO gasifier. Further tests were performed in January to April and June 1998. The longest cycle during this period was 25 hours. The max. gas production rate was 80 % of design capacity.

Some tests were stopped due to limitations of power generation by the public grid or by failures of the DCS system during switch-over to the gas turbine.

On March 20, 1998 the first coal gas was burned in the gas turbine. The coupling of the gas island with the power block regarding boiler feedwater, steam, and coal (clean) gas is now a standard procedure, which also applies to the switch-over from natural gas to coal gas and switch-back to natural gas.

Up to mid-June a total of 198 hours of raw/clean gas production was reached, i.e. operation of coal preparation unit, PRENFLO gasification unit and desulphurization unit.

Two major problems did not allow to collect more gas island operating hours.

The first problem was a motor failure of the waste nitrogen compressor in the air separation unit which led to a downtime of approx. 7 weeks in April to June. After some tests in June the operation had to be interrupted due to a problem of the gas turbine. This period of interruption will be approx. 9 weeks, i.e. further coal gas generation is scheduled for the end of August 1998.

Table 1 shows the composition of the fuel dust.

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<tr>
<th></th>
<th>Design</th>
<th>Actual</th>
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<tr>
<td>C</td>
<td>wt %</td>
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<tr>
<td>H</td>
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<tr>
<td>N</td>
<td>wt %</td>
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<tr>
<td>O</td>
<td>wt %</td>
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<td>S</td>
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<tr>
<td>Ash</td>
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<tr>
<td>Water</td>
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<tr>
<td>Total</td>
<td>wt %</td>
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</tr>
<tr>
<td>HHV</td>
<td>MJ/kg</td>
<td>24.0</td>
</tr>
</tbody>
</table>
Table 1: Fuel data

Generally, the fuel composition is very close to the design figures. Especially, the critical mixing process of raw coal and petroleum coke ensured a mix fuel of constant quality.

The clean gas composition is shown in Table 2

<table>
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<th></th>
<th>Design</th>
<th>Actual</th>
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<tbody>
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<td>CO₂</td>
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<tr>
<td>CO</td>
<td>vol %</td>
<td>60.5</td>
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<tr>
<td>H₂</td>
<td>vol %</td>
<td>22.1</td>
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<tr>
<td>N₂ + Ar</td>
<td>vol %</td>
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<tr>
<td>H₂S + COS</td>
<td>ppmv</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>vol %</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2: Clean gas composition (dry)

The achieved solids (dust) content in the clean gas at the outlet of the desulphurization unit is lower than 0.3 mg/m³n (design: 3 mg/m³n) which indicates a good performance of the candle filters.

The HP and IP boiler generated the expected amounts of steam based on excellent performance of the surface cleaning device (rapping system).

COMMISSIONING PROBLEMS

General problems during commissioning of the gas island:

1. Coal preparation unit

   Besides mechanical problems, i.e.
   - the screw feeders under the bag filters are very long and require an additional support in the centre,
   - high coal carry-over from the mill tables could be solved by an elongated chute within the mill,

   the produced fuel dust (mixture of coal and petroleum coke) was too fine. Parameter corrections of the siftener (classifier) and the grinding force between rollers and table influence the grain size distribution.

2. PRENFLO gasification unit

   The main problem at the beginning was the coal dust sluicing system, i.e. the transport of coal dust by gravity from the lock hoppers to the feed bin under elevated pressure. The flow rate was insufficient and not stable. A design modification was successfully tested and this will solve the problem.

   The slag water system caused some trouble due to high fines which occasionally overloaded the existing pressure filters.
3. Desulphurization unit

The MDEA unit including COS hydrolysis, Figure 6, could be well operated, however with the problem of accumulation of water condensate in the solvent circuit. This will be eliminated by a modified temperature level at the top of the desorber. The achieved desulphurization degree complies with the design figure and is far below the guarantee figure. The amount of 12 ppmv $\text{H}_2\text{S} + \text{COS}$ in the clean gas results in a $\text{SO}_2$ content in the flue gas from the power block of less than 10 mg/m$^3$n.

OUTLOOK

We are confident that the further commissioning and operation of the gas island including PRENFLO gasification will reach the guaranteed data and that very soon the 100-hour test can be performed.

The availability of the complete IGCC system is the basis for the success of this new technology for power generation from coal in the future.

Further developments permit higher efficiencies and also reduce investment costs.

A study performed by Siemens, the University of Essen and Krupp Uhde for the European Commission (within the framework of the JOULE III programme) results in 51.7 % net efficiency and 1,100 US $ per KW investment costs.