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World's largest IGCC celebrates 10th anniversary

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Introduction

This paper describes the world's largest IGCC based on solid feedstock, a mixture of petcoke and coal, at ELCOGAS in Puertollano, Spain. Uhde's PRENFLOTM process is used for the gasification of high-sulfur petcoke and high-ash coal. Operational results and lessons learned in the last 10 years are described.

For more than 65 years now Uhde (incorporated with Heinrich Koppers and Krupp Koppers) has been active in the field of coal gasification technology, especially entrained-flow gasification with dry coal dust feeding.

At the moment Uhde is involved in several projects in the United States based on PRENFLO coal gasification for the generation of electric power and the production of liquid fuels.

In addition, the new PDQ process (PRENFLO with Direct Quench) will be presented. It is a total water quench mainly for chemical application.

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1. The world's largest IGCC in Puertollano

1.1 General description

The IGCC plant owned by ELCOGAS (a consortium formed by European utility companies, e.g. Endesa, EDF, Iberdrola, EDP and Enel) in Puertollano/Spain, Figure 1 below, has a capacity of 300 MWe net and is still the largest IGCC plant in the world to use a single gasifier and gas turbine. The plant can be divided into 3 main parts as seen in

Figure 2: the 1) Air Separation Unit (ASU), 2) Gasification Island, and 3) Power Block. Uhde was responsible for the gasification island which includes the following units:

- Fuel preparation unit consisting of 2 trains
- PRENFLO gasification unit
- Desulfurization unit with MDEA
- Sulfur recovery unit with hydrogenation

It is the only plant worldwide to use the highly integrated system, i.e. the total air for the ASU is supplied by the compressor of the gas turbine.

A mixture of 50% high-sulfur petcoke and 50% high-ash coal is gasified. Electric power from coal gas was first generated in March 1998.



Figure 1: IGCC plant in Puertollano/Spain

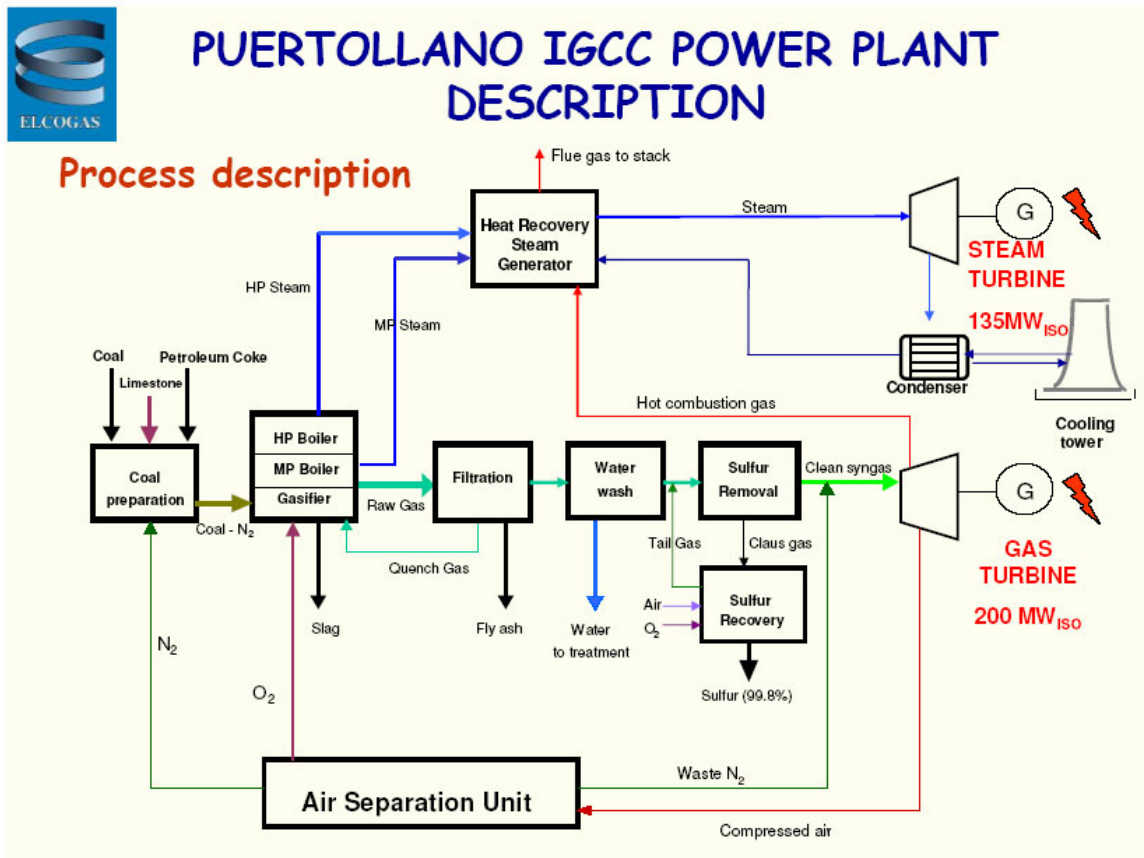


Figure 2: Block diagram of the IGCC plant in Puertollano/Spain

1.2 Lessons learned

The first years were crucial to demonstrate the commercial feasibility of IGCC plants. Lessons learned is of high value for future plants and it will allow increased availability and decreased investment and O&M cost.

The availability of the total IGCC plant is mainly influenced by two units: the gas turbine within the power block and the gasification. An extraordinary case at the end of last year was the damage to the coupling of the waste nitrogen compressor, belonging to the ASU, which led to a complete shutdown of the gasification island. A new coupling was available at the beginning of May this year and will again result in low operating hours for 2008.

The main problem relating to non-production hours within the gasification unit are the candle filters. A “wrong” design, supporting the standing candles and the connection to the gas collector (sealing of the ceramic candles with the steel collector) is a problem and leads to shorter lifetime due to leakages.

Figure 3 shows the main reasons for unavailability in the year 2007 which results in 4,332 electric power production hours only based on coal gas.

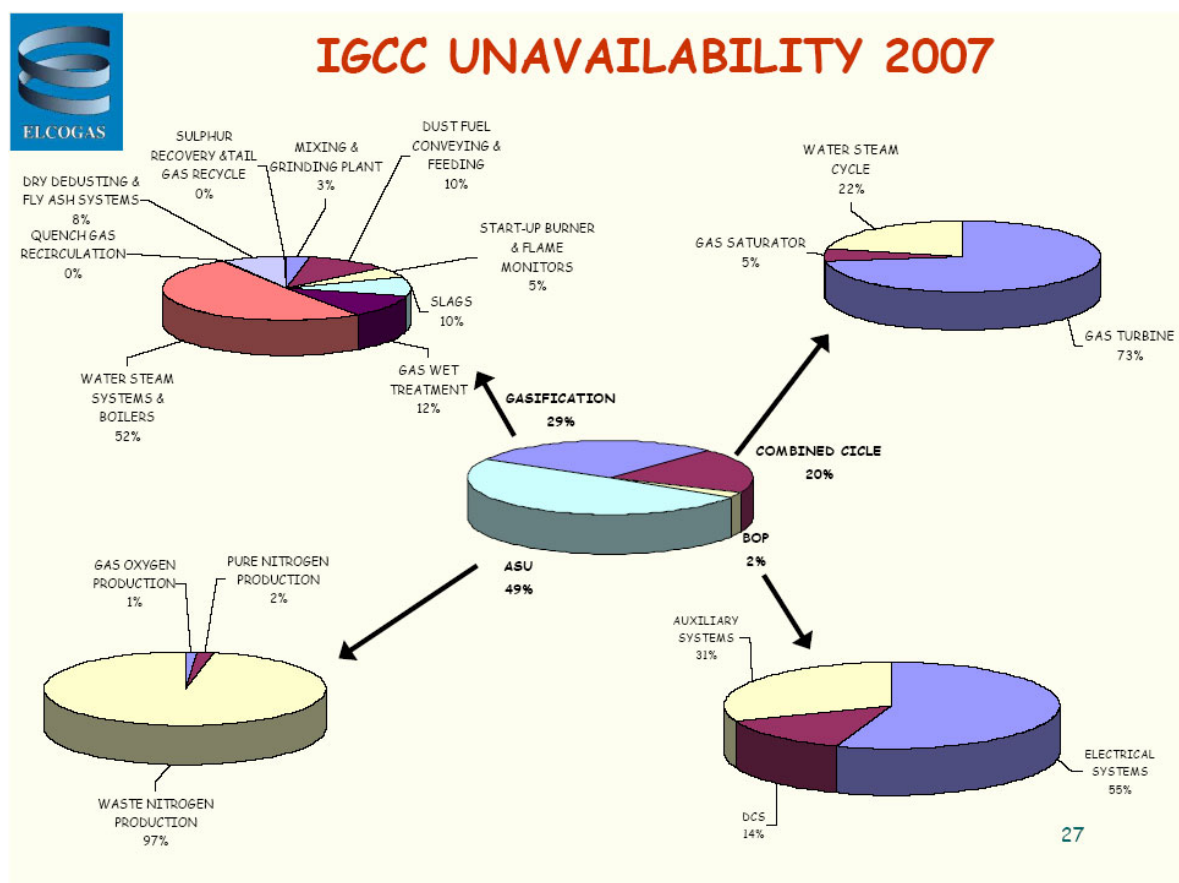


Figure 3: Unavailability of the IGCC plant in 2007

1.3 New investigations

1.3.1 Pilot plant for H₂ production and CO₂ recovery

The pilot plant, Figure 4, has the possibility to test sour and sweet CO shift as well as various systems for CO₂/H₂S or only CO₂ removal. The raw gas can be taken upstream of the sulfur removal or as desulfurized gas downstream of the sulfur removal. The raw hydrogen can be added downstream of the gas saturation in front of the combined cycle. For the production of hydrogen with a purity of 99.99 vol% a PSA unit will be installed.

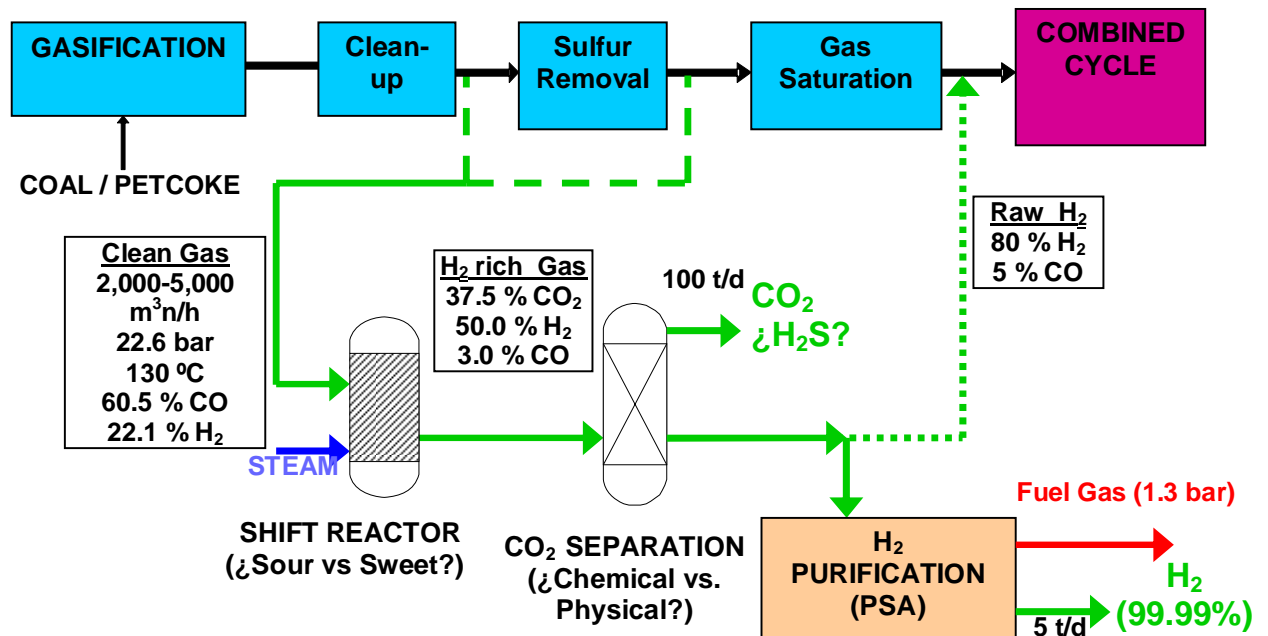


Figure 4: Block diagram of the pilot plant in Puertollano/Spain

The capacity of the pilot plant is 2,000 to 5,000 m³/h raw gas or clean gas and the hydrogen production is 5 t/d. Construction of the plant will be finished in the middle of 2009.

1.3.2 Liquid fuel production

ELCOGAS will install a small test unit for the production of liquid fuel from the syngas.

1.3.3 Additional fuels for gasification

Several materials have already been gasified or will be gasified in the near future together with the main fuel, Table 1.

Ultimate analysis		Puertollano		
		Coal	Petcoke	Mixture
C	wt. %	36.3	82.2	59.2
H	wt. %	2.5	3.1	2.8
N	wt. %	0.8	1.9	1.4
O	wt. %	6.6	--	3.3
S	wt. %	0.9	5.5	3.2
Ash	wt. %	41.1	0.3	20.7
Water	wt. %	11.8	7.0	9.4
Total:	wt. %	100.0	100.0	100.0
LHV	MJ/kg	13.1	32.6	23.1

Table 1: Analysis of main fuel (petcoke and coal)

One of the interesting materials was MBM (Meat and Bone Meal), a risk material due to BSE. The material can be described as SRM (Specific Risk Material) - spinal marrow, bones, spleen or brain -, HRM (High Risk Material) – remaining animal parts - and BS (Blood Stuff) – dried animal blood. The high gasification temperature destroys all harmful components. Table 2 shows the parameters of this material. Up to 4.5 % of this material has been added to the main fuel in the past.

Parameter		SRM	HRM	BS
Weight loss at 100°C	%	2.54	5.03	14.96
Volatile	%	65.27	63.7	65.27
Ash	wt. %	26.13	25.54	1.45
Cl	mg/kg	3,420	2,560	6,500
HHV	MJ/kg	20.09	18.92	23.26

Table 2: Parameter of Meat and Bone Meal

This year waste material from olives has been gasified together with the main fuel. The percentage of the biomass material has so far been 2% (2 t/h) and is expected

to reach 10 % end of 2008. Table 3 shows the parameters of olives waste consisting of the fruit remains including stones.

Ultimate analysis		
C	wt. %	44.0
H	wt. %	6.0
N	wt. %	1.2
O	wt. %	26.3
S	wt. %	0.1
Cl	wt. %	0.2
Ash	wt. %	7.2
Water	wt. %	15.0
HHV	MJ/kg	17.17

Table 3: Analysis of olives waste

For 2009 it is planned to gasify car manufacture wastes (shredder fibers), Table 4, together with the normal fuel.

Ultimate analysis		
C	wt. %	53.19
H	wt. %	6.47
N	wt. %	1.64
O	wt. %	15.11
S	wt. %	0.27
Cl	wt. %	1.97
Ash	wt. %	19.64
Water	wt. %	1.71
HHV	MJ/kg	24.14

Table 4: Analysis of shredder fibers

2. PRENFLO with Direct Quench (PDQ)

PRENFLO is back - the PRENFLO Direct Quench (PDQ) process is an optimised design of the proven PSG (PRENFLO with Steam Generation) gasification process for chemical applications or IGCC plants with Carbon Capture and Storage (CCS). It combines the technologically advanced dry feed system, multiple burners and membrane wall of the PSG process with a proprietary water quench system. The total water quench saturates the raw syngas with water/steam for subsequent gas treatment, e.g. CO shift conversion. Figure 5 shows the flow diagram of the PDQ process.

The gasification zone with the burners is identical to the PSG version except that the burners are shifted horizontally from the bottom to the top. The gasifier includes the gasification zone (membrane wall) as well as the quenching devices. The saturated

raw gas is available at the outlet from the gasifier/direct quench with a temperature of approx. 200 to 250°C.

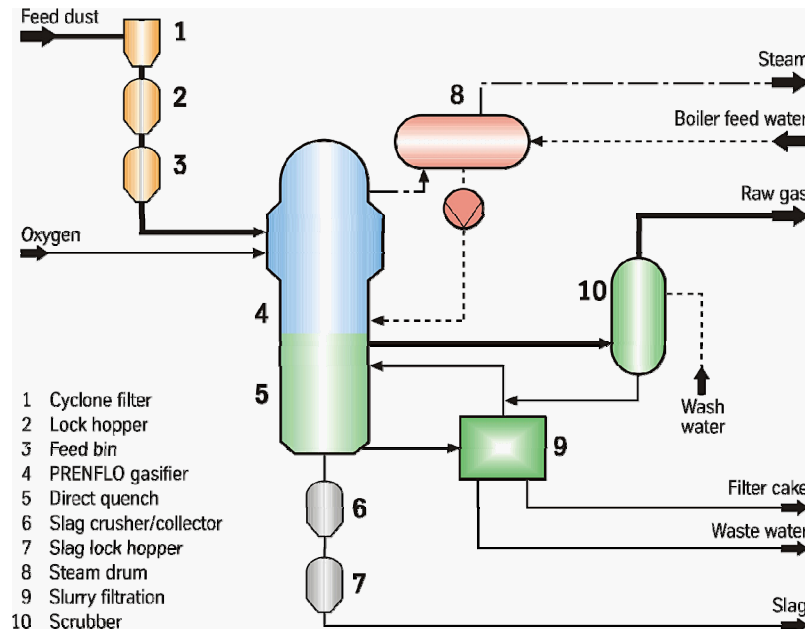


Figure 5: Flow diagram of the PRENFLO (PDQ) process

A layout comparison between PSG and PDQ is shown in Figure 6. It is not only the height of the gasification structure but also the plant area which is reduced. The new PDQ design allows a reduction in the gasification structure height from approx. 76 m to approx. 50 m.

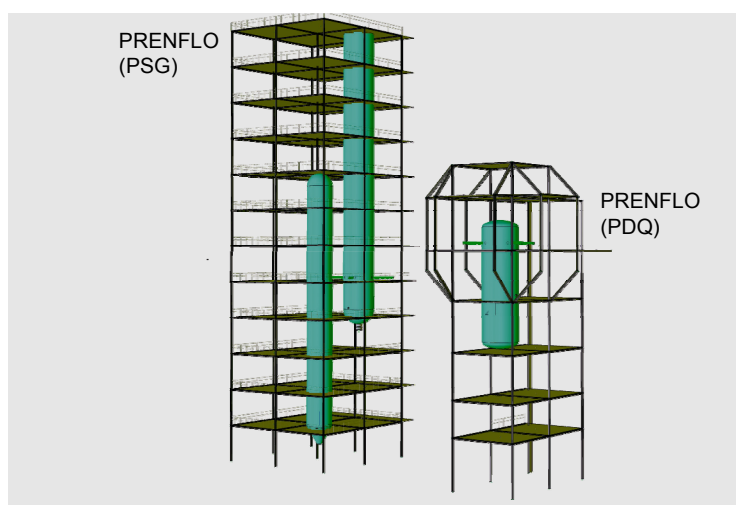


Figure 6: Layout comparison of PRENFLO PSG and PRENFLO PDQ

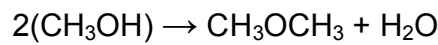
3. Liquid fuels production

For the production of liquids from coal or other carbon-containing materials, the Methanol-to-Gasoline (MTG) route is preferred, Figure 7.

Uhde cooperates with ExxonMobil Research and Engineering (EMRE) as the licensor in the field of MTG technology.

The fixed-bed MTG process is based on a shape selective zeolite catalyst.

In the first step, methanol is dehydrated to dimethylether according to the following reaction:



In a next step dimethylether is dehydrated and light olefins are formed. The light olefins react to paraffins and naphthalenes. Aromatics are formed by complex reactions. The main reactions are:



The MTG plant for JAM (Shanxi Jincheng Anthracite Coal Mining Co. Ltd./China) with a capacity of 2,600 bbl/day or 100,000 tons/year gasoline is in the final erection phase. The startup for the first CTL plant using MTG is planned for the end of 2008. The goal is to build a plant with a capacity of 26,000-bbl/day or 1,000,000 tons/year gasoline.

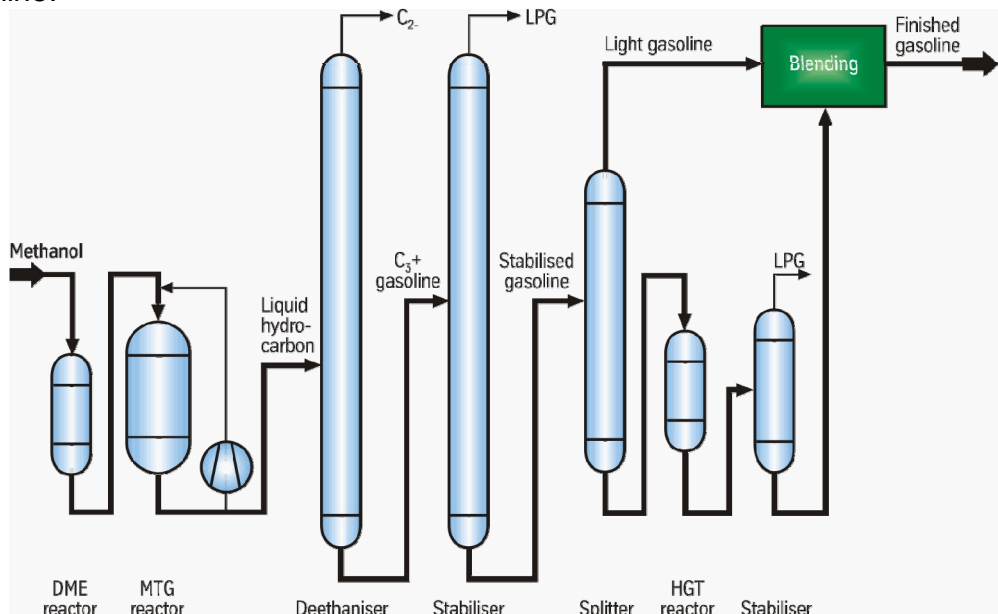


Figure 7: Flow diagram of the fixed-bed MTG plant

This year Uhde performed the engineering work for the DKRW project in Carbon County, Wyoming for EMRE. The capacity of the plant is 18,000 bbl/d or 690,000 tons/y gasoline based on coal gasification. The CO₂ removed will be used for enhanced oil recovery.

4. Outlook

The ELCOGAS IGCC plant in Puertollano has demonstrated over the last ten years clean power generation from petcoke and coal. With the addition of biomass or other carbonaceous materials the flexibility of feedstocks has been or will be demonstrated. Lessons learned from existing IGCCs are a good chance for new plants. IGCC technology provides the basis for CO₂ capture and storage (CCS).

The increasing demand in energy, especially for electric power and gasoline/diesel, based on the enormous growth in Asia (e.g. China and India) will lead to the further use of coal and biomass.

Many projects worldwide show interest in coal gasification for the production of ammonia, methanol, liquid fuels (gasoline, diesel) and/or the generation of electricity.

The last sentence in this outlook is the same as the year before but even more valid: **The high increase in natural gas and oil prices offers chances for coal gasification.**

Abbreviations

ASU	Air Separation Unit
bbbl/day	barrels per day
BSE	Bovine spongiforme encephalopathy
CCS	Carbon Capture and Storage
CTL	Coal-to-Liquids
DKRW	DKRW Advanced Fuels
DOE	Department of Energy (USA)
EDF	Electricité de France
EDP	Electricidade de Portugal
EMRE	ExxonMobil Research & Engineering
HHV	higher heating value
IGCC	Integrated Gasification Combined Cycle
m ³ n/h	normal cubic meter per hour
MBM	Meat and Bone Meal
MDEA	methyl diethanol amine
MJ/kg	megajoule per kilogram
MTG	Methanol-to-Gasoline
O&M	operating & maintenance
PDQ	PRENFLO with Direct Quench
PRENFLO	PREssurized ENtrained-FLOW
PSA	Pressure Swing Adsorption
PSG	PRENFLO with Steam Generation
t/d	metric tons per day
t/year	metric tons per year