ENI REFINING & MARKETING
SANNAZZARO GASIFICATION PLANT
PROJECT UPDATE AND START UP EXPERIENCE

Gasification Technologies 2006
Washington, DC
October 1-4, 2006

Dario Camozzi - Snamprogetti – Italy
Raffaella Lucarno – Eni Refining & Marketing – Italy
Joachim Wolff – Shell Global Solutions – The Netherlands

Introduction

Following the new regulation introduced in Europe in the last years, defining more stringent limits for the emissions to the atmosphere, the necessity to find an alternative use for the fuel oil has created a new challenge for refineries.
Progressive reduction of heavy residue market obliged refineries to reduce this production or to find new utilization. This reduction is mainly due to Italian power production that will use more gas than fuel oil for environmental and economic reasons.

At the same time the need to improve the Italian power production pushed Eni, the Italian energy company, to enter the electricity market.

In this frame Eni decided to build a new combined-cycle power plant of 1,050 MWe fed by both syngas and natural gas in the industrial area of Sannazzaro, in northern Italy,.
A new gasification plant, based on Shell Gasification Process (SGP) has been constructed by Snamprogetti at the Eni R&M refinery, for the production of syngas and hydrogen for internal use.
The gasification plant is integrated with the nearby 1,050 MWe power plant of EniPower (a company of ENI), feeding the syngas to one 250 MWe combined-cycle. Additional 800 MWe are produced by two high efficiency NGCC.

Over the last four years the Sannazzaro project has been carried out by Snamprogetti under an EPC contract up to the mechanical completion including part of pre-commissioning activities.

In April 2006, following a smooth start up, the gasification section entered commercial operation becoming the 4th Italian IGCC based on refinery residues.

The paper will cover an update of the project focusing on the gasification start-up experience and the performance achieved during the first period of commercial operation .

Project overview

The complex has considerable potential for power production and also guarantees:

- low emissions in atmosphere (SOx, NOx, particulate matter), according with the stringent European limits,
- bottom of the barrel valorization,
- good integration with the refinery

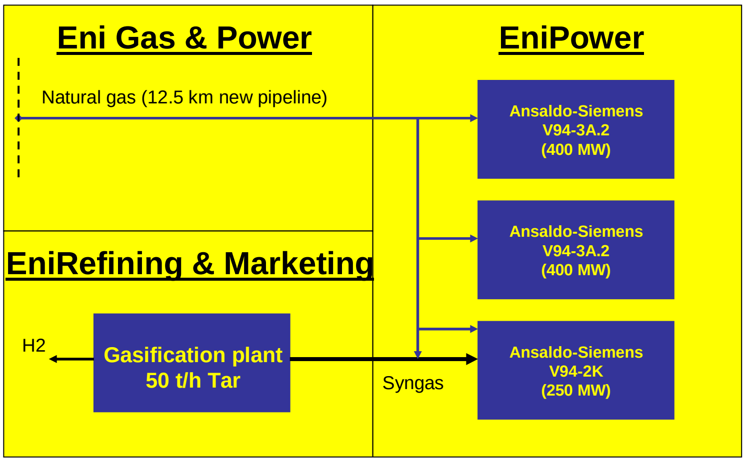
On those basis ENI Refining & Marking decided to build in Sannazzaro De Burgondi (in the North of Italy) a new gasification plant to treat 1,200t/d of Visbroken residue.

The gasification complex can produce:

- ✓ 38,000 Nm3/h of Hydrogen.
- ✓ 2,280 tons/d of syngas to be sent to EniPower (or 2,560 tons/d in case of no Hydrogen production), with a composition depending on Hydrogen extraction and varying in a defined range.

The Syngas is fed to EniPower to produce:

- ✓ 250MWe (without hydrogen production) in the nearby Combined Cycled Plant owned by EniPower.

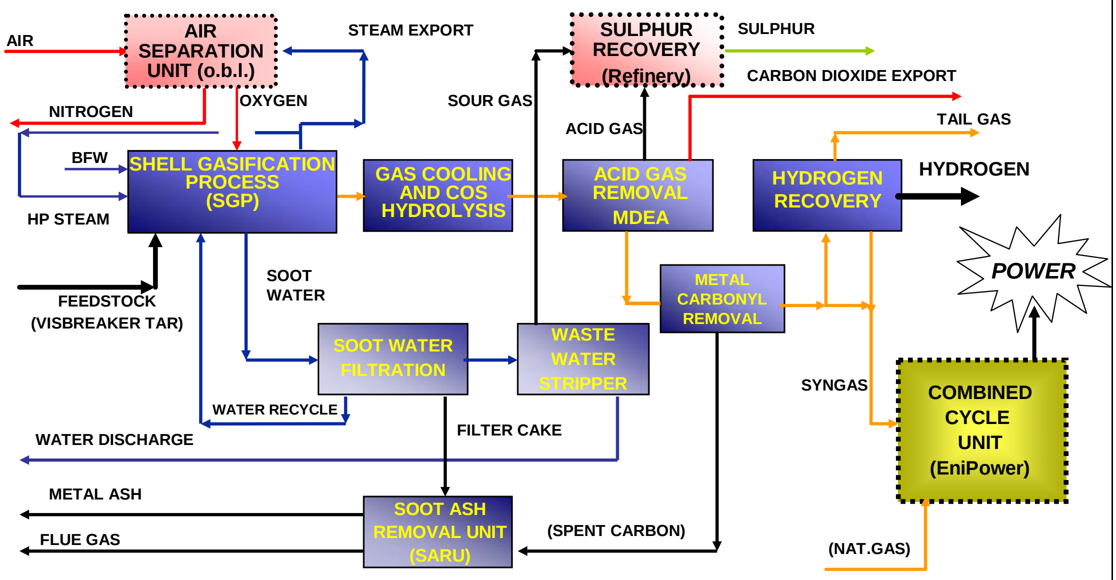


Schematic Complex Block Diagram

These features have been chosen for the Gasification plant configuration:

- Two gasifiers with 50% capacity;
- Syngas heat recovery with steam production;
- Waste Heat Exchanger with internal superheater to maximize heat recovery *(first of a kind)*;

- Soot Ash Removal Unit to minimize the solid waste production creating a vanadium concentrate easier to handle;
- Hydrogen recovery unit to obtain a valuable utility for refinery that requires more hydrogen for the desulphurization process;
- Chemical H_2S removal to guarantee the low limit of sulphur content in the syngas and emissions from Power Station stack;
- Carbon dioxide recovery available for selling;
- Metal-Carbonyls Removal Unit to avoid formation of metal deposit in the gas turbine burners *(first of a kind)*.



Process Block Diagram

Project Summary

• Contract duration	11.2002 – 11.2005
• Basic & Detail Engineering	11.2002 – 02.2005
• Contract Conversion to EPC LS	07.2003
• Materials Procurement	07.2003 – 10.2004
• Construction and Precommissioning	10.2003 – 11.2005
• Commissioning	11.2005 – 03.2006
• Start up and Commercial Operation	03.2006 – 04.2006
• Test run	06.2006

GASIFICATION PLANT DESCRIPTION

Feedstock

The design gasification feedstock is vacuum flashed visbroken residue with the following main characteristics

Data on dry basis		Design
Carbon	%wt	85.73
Hydrogen	%wt	9.05
Sulphur	%wt	3.54
HHV (* = calculated)	MJ/kg	41.28
LHV (* = calculated)	MJ/kg	39.30

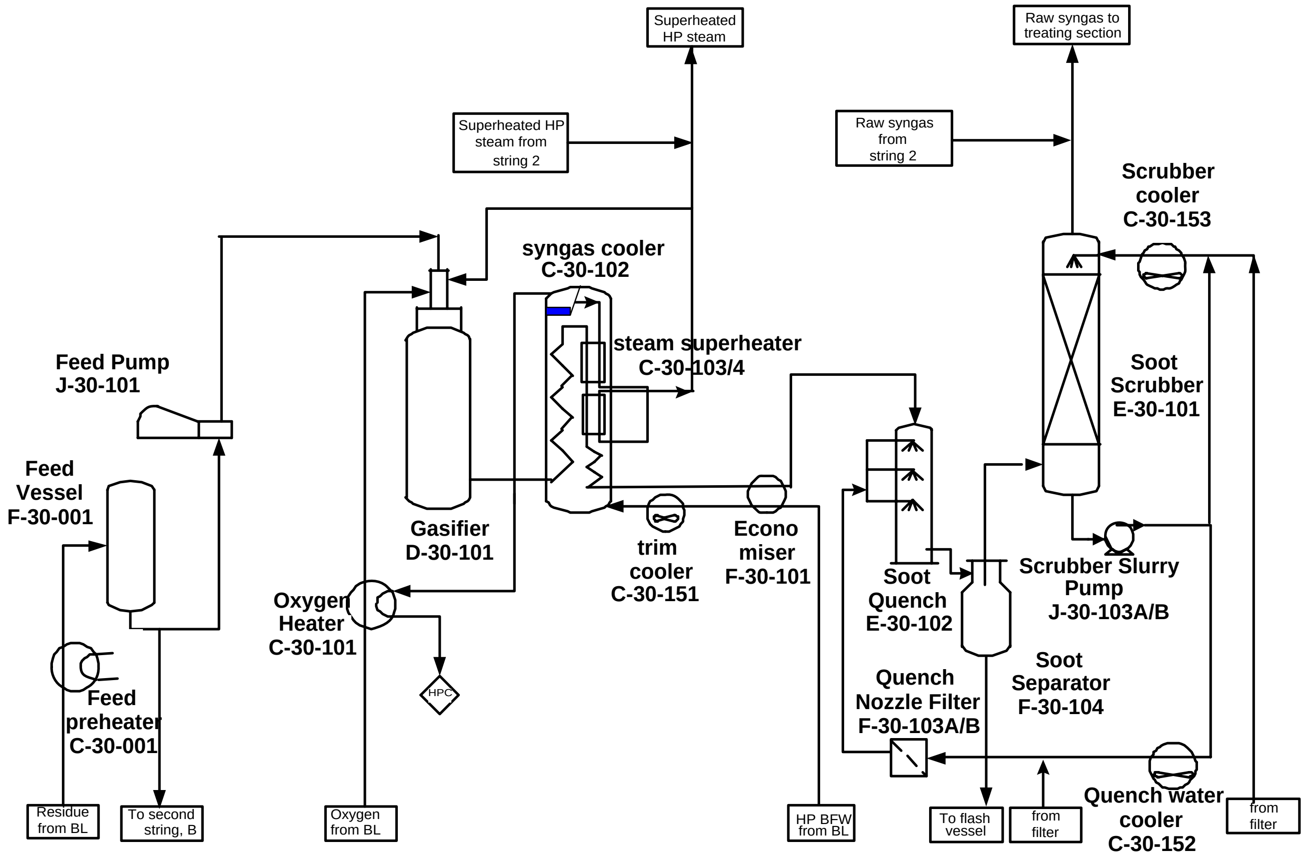
Shell's indication and present operating experience have shown that main parameters to follow for smooth operation are: viscosity and ash content. The other figures (C, H, S) are not very important if they vary in a limited range. In this case it is important to adjust the O_2/oil ratio in such a way to keep correct reactor temperatures and methane slip. This capability to manage different feedstock has proven to be very useful to refinery necessity.

Oxygen at 99.5%v purity is supplied from an air separation unit located outside the battery limit and is preheated prior to being introduced into the gasifiers.

Gasification

The non-catalytic partial oxidation of hydrocarbons by the *Shell Gasification Process (SGP)* takes place in a refractory-lined gasifier equipped with a specially designed, co-annular burner. This design provides efficient gas/liquid mixing and a good flame temperature control. The oxygen, at 99.5 %v purity, is preheated with saturated steam from the syngas cooler and mixed with superheated steam as moderator prior to feeding to the burner. The burner and reactor are designed and tuned such that this mixture is intimately mixed with the feedstock within the reactor.

Two gasification strings are provided, each having a capacity of 600 t/d of visbreaker tar.
The residue, directly from the visbreaker or supplied from tankage, is run down into a common feed vessel. The feedstock once preheated at a controlled temperature value is supplied to the gasifier using a reciprocating feed pump, one for each string, plus a common spare.
Gasification takes place at a pressure of 62 barg; the temperature of the syngas entering the syngas cooler is approx. 1300 °C.



Simplified Process Flow Diagram of SGP

Syngas Cooling

Primary heat recovery takes place in a Waste Heat Exchanger with superheater section generating high pressure saturated as well as superheated steam.
The internal superheater modules make the Sannazzaro WHE peculiar, being the first commercial experience and giving the opportunity to the Gasification unit to be independent from other superheated steam producers. Only a part of the saturated steam, produced in the evaporator, is therefore exported for preheating purpose in the plant, while the majority is superheated, internally the WHE, to produce high pressure superheated steam. The superheated steam is used as process steam to feed the gasifier, while the surplus is exported to feed the air compressor steam turbine in the offsite ASU.
The saturated steam generated is used inside the plant for oxygen preheating and, if needed, for feed preheating.

Secondary heat recovery takes place in a boiler feed water economizer.

Soot Removal

In the partial oxidation of hydrocarbons the product gas contains a certain amount of free unconverted carbon and ash (soot). The soot is removed in two stages from the gas by means of a quench pipe arranged with a soot separator followed by a packed scrubbing tower, the soot scrubber. Most of the soot is removed in the quench pipe by a direct water spray.

In the scrubber the gas is washed by water in counter current flow. After leaving the scrubber at a temperature of about 120°C, the gas is suitable for further treating in the HCN/COS catalytic hydrolysis unit / acid gas removal unit.

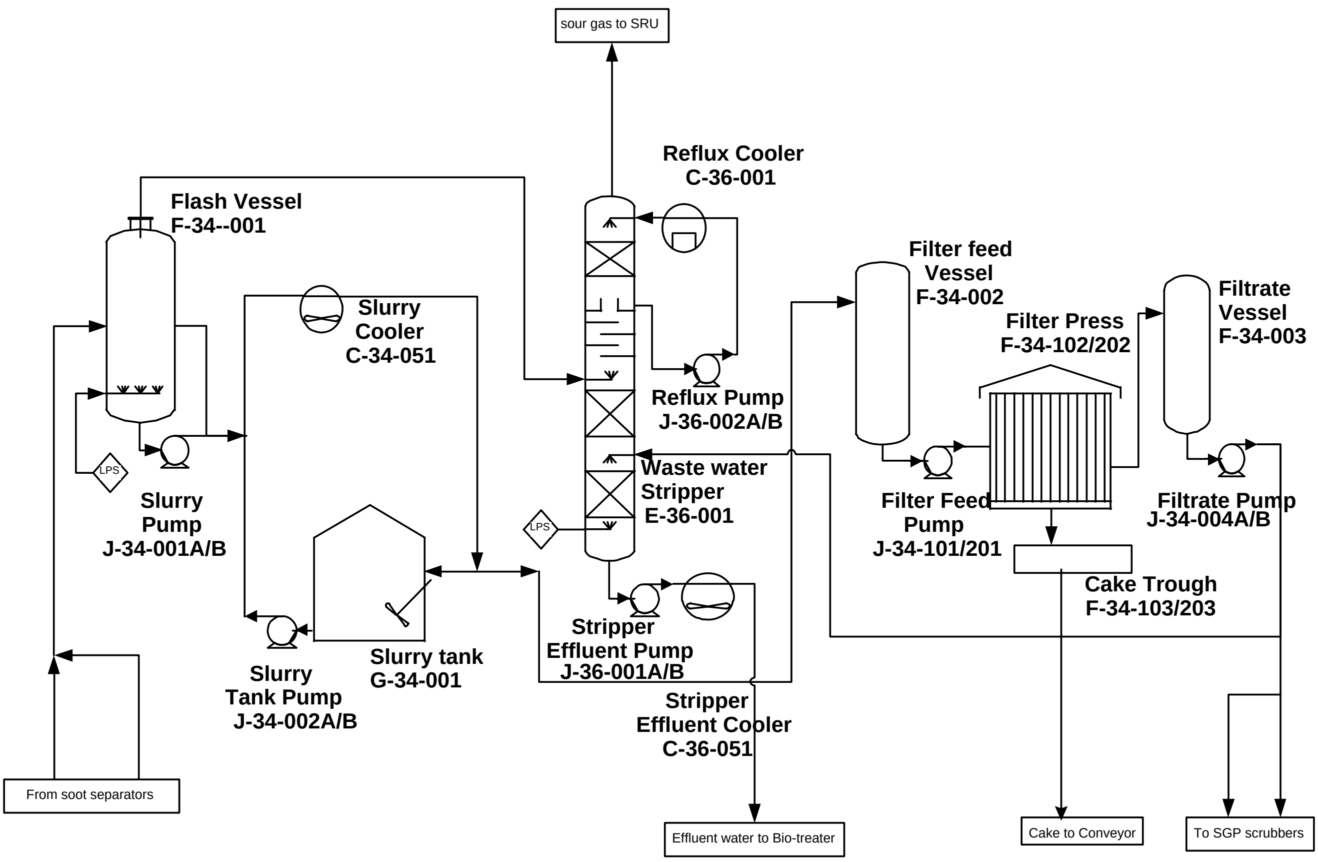
The soot formed in the partial oxidation reaction is removed from the system as a soot slurry via the bottom outlet of the carbon separators and is routed to a common slurry system for further processing.

Soot slurry processing

The slurry ex carbon separators is let down to low pressure in a common slurry flash vessel to flash off dissolved syngas components like H_2, CO and acid gas (NH_3, H_2S). This gas is routed to the Waste Water Stripper (WWS).

The flashed soot slurry is routed to the filter feed vessel.

Carbon slurry filtration takes place in two membrane filter presses (one spare) operating in batch mode.
The produced filter cake will have a soot ash content between 15 and 25 %wt and is fed to the Multiple Hearth Furnace where the carbon part is burnt and ash produced. The Ash has a commercial value as feedstock for the metal reclaiming industry, in particular as vanadium source.



Simplified Process Flow Diagram of Slurry Processing.

Waste water stripping

The waste water stripper receives the excess filtrate water (the part not utilised in SGP) from filter presses and flash gas from soot slurry flash vessel as well as process condensate from the acid gas treating unit.
The sour gas is sent to the existing refinery sulphur recovery facilities.

COS/HCN hydrolysis and Acid Gas Removal

The raw syngas requires further treatment to a specified purity in order to make it suitable for H2 production and for electric power generation in a gas turbine.
COS/HCN Hydrolysis and Syngas Cooling Unit convert most of the COS and HCN in the syngas feed to H2S and NH3 via catalytic hydrolysis reactions, and cool the syngas to suitable temperatures for the Acid Gas Removal Unit. The Acid Gas Removal Unit removes most of the H2S from the syngas to meet environmental emission regulations. Sulfur containing acid gas removed from the syngas is sent to the existing Sulfur Recovery facilities in the refinery.
The hydrolysis process is licensed by *Shell Global Solutions* while the amine process utilizes *Dow Gas-Spec* solvent.

Metal Carbonyls Removal

The purpose of the Metal Carbonyl Removal Unit is to remove few ppm of iron and nickel carbonyls in the syngas downstream the Acid Gas Removal Unit. They are removed by physical adsorption with activated carbon. Although they are present in trace quantities, they could cause operational problem to the downstream gas turbine.
The spent carbon contains adsorbed metal carbonyls. When the carbon is saturated it is burnt in the MHF of SARU, and metal carbonyl thermally decomposed and converted to metal ash (oxides).

Hydrogen Recovery

The unit has been designed to produce 38,000 Nm^3/h of hydrogen with a purity of minimum 99.9%v. This is achieved by means of UOP licenced membrane system followed by a Pressure Swing Adsorbtion (PSA).
The hydrogen selectively permeates into the bore of the membrane fibres pushed by the differential pressure across them. The hydrogen depleted non-permeate gas is available essentially at the feed pressure, and sent to the gas turbine.

Syngas Quality

The treated syngas is made available to the Power plant at about 80°C and 20 barg, and with a molar ratio H2/CO between about 0.4 and 1 depending on the hydrogen extraction. The low heating value of the syngas (dry) ranges between 2,800 and 3,700 kcal/kg, and in the lower case it is adjusted in the power plant by a small (about 10%) addition of natural gas.

Commissioning and start up schedule for the Gasification and Gas Treatment

The gasification plant based on basic PDP from Shell Global Solutions was built by Snamprogetti under an EPC contract up to the mechanical completion including part of the pre-commissioning activities.
The plant was handed over on 17th November 2005.
The commissioning period started in the same day and it lasted till the 23rd March 2006, when the first gasifier was attempted to be started up for the first time.
Commissioning shown linear operation as per schedule, following licensor indications for tests and operation sequences.
SU and SD ESD sequences have been tested with inert medium (N2, steam, etc…) after the Factory Acceptance Test (FAT) and the blank test on field was successfully completed. It was proven to be very useful to check everything, from field to control room, before the start up.

At the beginning the first train was started up on 23rd March *(1st attempt).*

Start up was successful at 4th attempt (on 25th March) due to some spurious trip occurred on previous. Continuous operations (33 days) started from 5th attempt (27th March) and anyway only after 4 days from the first start up; confirming the good impression had during the commissioning phase.

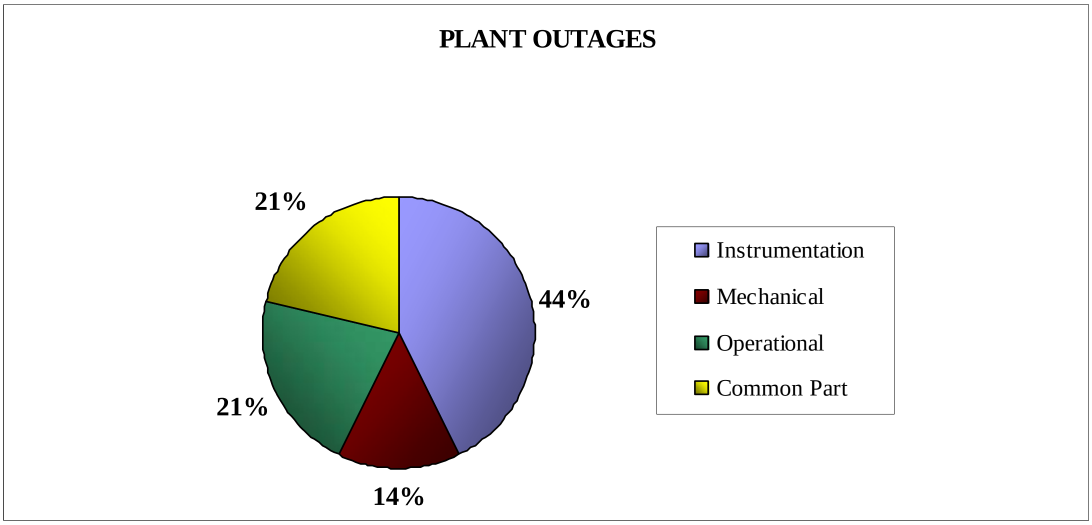
The second train saw the first start up on 19th April, but it began to work properly from the 29th April due to some leakages problem on syngas line to Scrubber. Even in this case continuous commercial operation was reached after only few days from the first start up.

<u>Summary</u>	**Duration**	
Commissioning	127 days	From 17th November'05 to 23rd March'06
Start-up Train 1	5 days	From 23rd March'06 to 27th March'06
Start-up Train 2	11 days	From 19th April'06 to 29th April'06
Overall Start up	38 days	From 23rd March'06 to 29th April'06

During the period and till 31st July there had been 14 outages in total due to following reasons within the gasification and gas treatment section.

Cause of shutdown	**1st train**	**2nd train**
Instrumentation	6	0
Mechanical	2	2
Operational	1	2
Common part	1	1
Total	**14**	

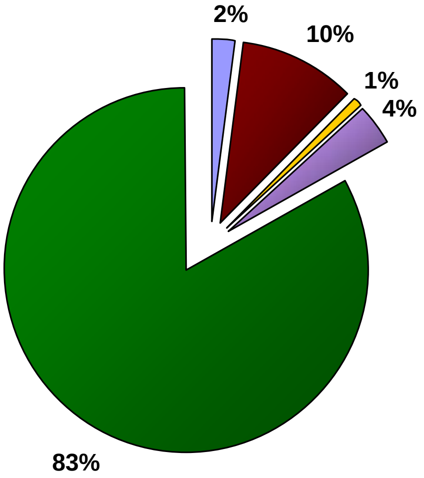
Causes of Unit Shutdown:



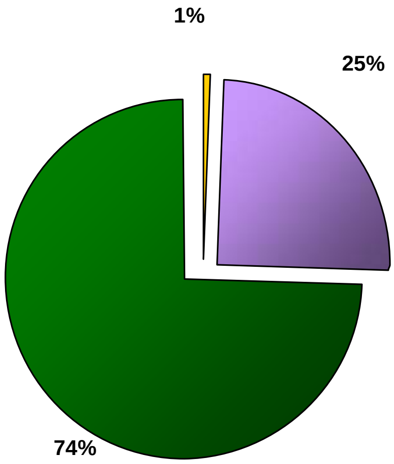
Although instrument and control logic problems, sometimes spurious intervention, are the greater cause of outages, the duration of downtime is usually very limited in case of instrumental problems. Instead mechanical problems normally brings to longer downtime and forced outages required to fix the problem; as it can be seen in the below graphs in which on stream factor and down time causes are weighed.

On stream factor has been 83% for train 1 and 74% for train 2 in the period.
The causes for unrequested downtime are reported in percentage divided by typology.

Train 1 (up to 07/31/2006)



Train 2 (up to 07/31/2006)



On stream

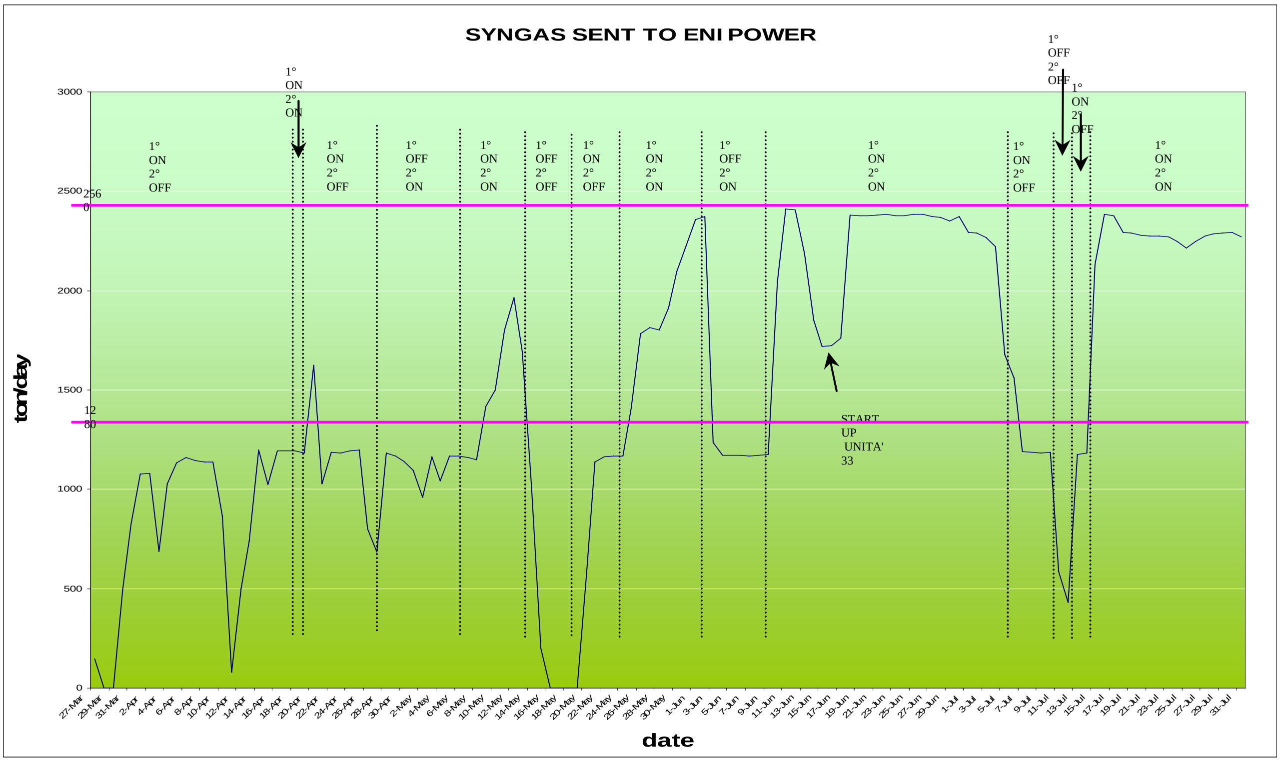
Operations

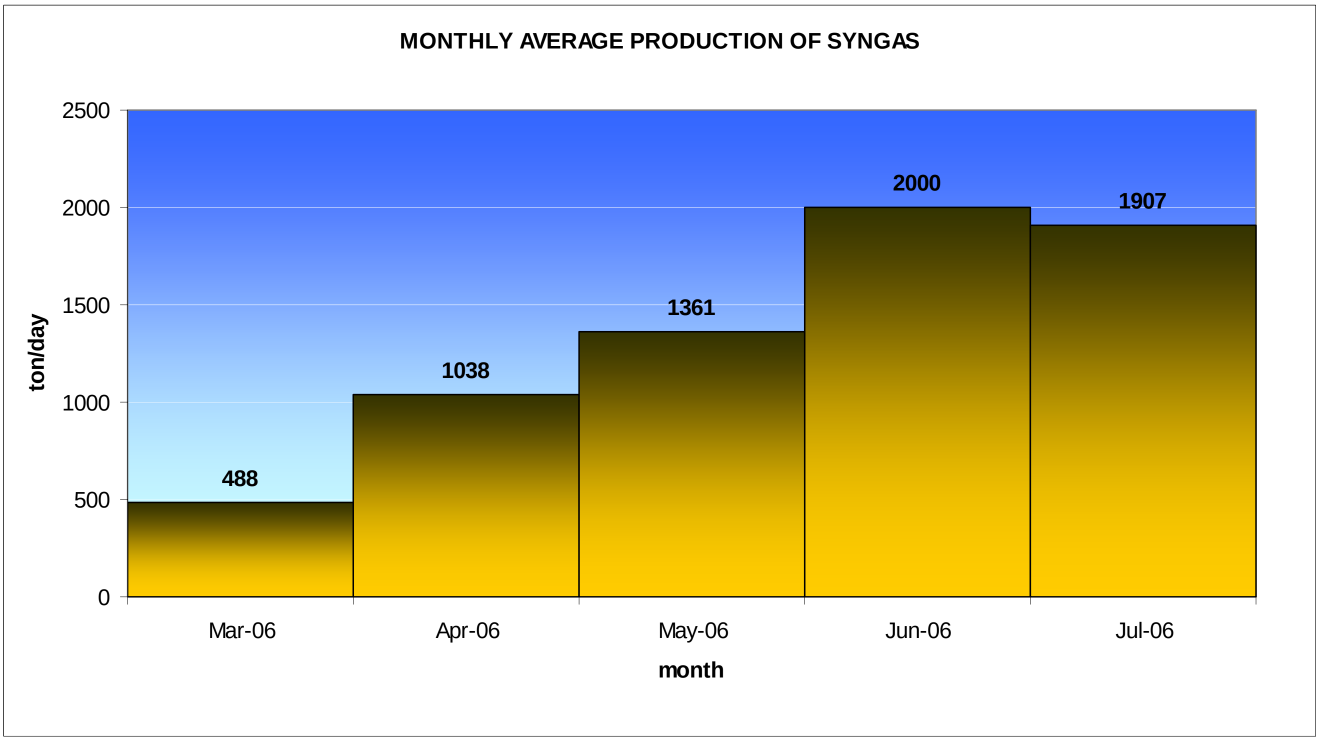
Instrumentation and Control; *problems related to instruments or control logic*

Mechanical

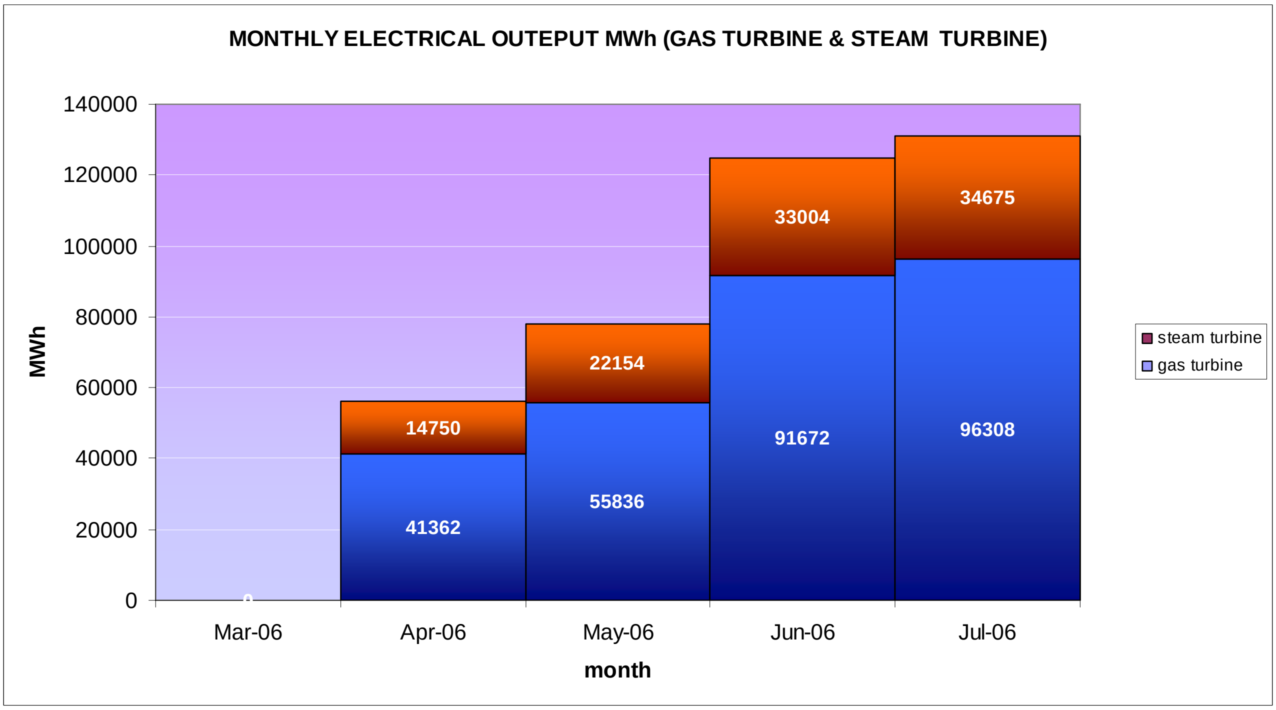
Common Parts; *problems that required the plant shut down to be solved*

From the start up the syngas production was the following





The power production from EniPower group 3 was:



The test run was performed at the end of June 2006.

Commissioning and Start Up Experience

The experience gained during commissioning and start up phases have shown some important improvements here below reported jointly to some issues to be mentioned as well.

Improvements

- Starting from the PDP, previous Pernis experience have been reflected on this project. However during both engineering and construction phases some further lessons learned have been also applied.
- The plant has a high level of instrumentation and automation both in terms of control and logic sequences. It has been found very appropriate to develop a detailed description.
- Start up and shut down sequences are completely automatic, acted and supervised by the Emergency Shut Down System (ESD)
- Tests of ESD sequences with inert medium (N2, steam, etc…) after Factory Acceptance Test (FAT) and blank test on field was successfully completed. It was proven to be very useful to check everything, from field to control room, before start up. This activity was time consuming, but it gave back the advantage to prove everything in detail with safe medium and prior to the real start up.
- Very low level of latent defect
- Use of nuclear level on solids, slurry and tar is reliable, but require an accurate commissioning and tuning procedure
- Burner ok after 3000 hours of operation changed during maintenance turn around.
- Refractory found out without any problem during inspection done during maintenance turnaround

Issues

- Mechanical problems related to leakages on high pressure BFW air cooler
- Soot deposition inside slurry tank gives problems to pump it back to be processed
- Newly developed Superheater coil failure *(happened mid August, still to be analyzed)*
- Water balance – It is important to take into account the effect of the flushing medium of the instrument that put water in the plant, and feed the WWS. The WWS should be designed accordingly.
- It is important to define a detailed specification for the solid handling systems covering all characteristics, to have a system properly working in terms of operability, maintainability and safety.

Commercial Operation and Performance Test

Following the commercial period started at the beginning of April the performance test of gasifiers has been carried out for 72 hours at the end ofJune'06; from 27th to 30th of June. During the test all streams have been tested and analyzed in terms of flow rate and composition:

Gasification capacity – Feedstock Flow Rate

	UM	Overall Test Average
Train 1	**t/h**	24.94
Train 2	**t/h**	25.44
Total	**t/h**	50.38

Syngas overall production (Specific Production expressed as: Nmc CO+H2 in the syngas per kg of feed).

	UM	Overall Test Average
Total	**Nmc**	2.80

Total Syngas Production:

	UM	Overall Test Average
Train 1	**kg/h**	57,905
Train 2	**kg/h**	56,881
Total	**kg/h**	114,786

Oxygen Specific Consumption (expressed as: kg of Oxygen per kg of feed)

	UM	Overall Test Average
Total	**kg/h**	48,581
Total	**specific**	0.963

Steam Production (Net exported value):

HPS superheated	UM	Overall Test Average
Totale	**t/h**	76.3

The tables show that all the SGP performance guarantee parameters have been satisfied all along the performance test even in terms of production either of specific consumption. Also the analysis of the main streams shown compositions and parameters as expected.

During the performance test all the unit section were running with the exclusion Hydrogen Recovery that was on start up at that moment. The unit was started up obtaining an hydrogen production quality of 99.9%v.

STATUS OF THE PROJECT

The gasification plant is now running at full capacity. Still some problems have to be fixed and solved, as reported in the previous chapter, like cake transport system , superheaters failure and slurry tank soot deposition. Also some tests have to be done in order to better evaluate the performances of single units; for example test of Hydrogen Recovery Unit at 100% of capacity.
Anyway the gasification plant has shown a very smooth and reliable start up coming into operations in a very short time with performances at high level of availability from the very beginning.

This proved that gasification technology is really today a mature technology; and we look forward to be part of new projects that can be valuable for both Owner and Contractor and also for the Environment.

REFERENCES

1. D.Camozzi, G.Collodi, A.Cavanna – "The new Gasification Project at ENI Sannazzaro Refinery and its Integration with 1050 MWe Power Plant" – Gasification Technologies 2004 – Washington DC – USA.
2. R.Lucarno. G.Malossi – "Integration of SGP into the Sannazzaro Refinery" – Shell Gasification Operators' Conference 2004
3. G.Collodi, D.Brkic – "The Experience of Snamprogetti's Four Gasification Projects for over 3000 MWth" – Gasification Technologies 2003 – San Francisco – USA.
4. J.D.deGraaf, A.Magri – "The Shell Gasification Process at the Agip Refinery in Sannazzaro" – Gasification-The Clean Choice for Carbon Management-2002 – Noordwijk – The Netherlands.