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ANSALDO ENERGIA GAS TURBINE OPERATING EXPERIENCE WITH LOW BTU FUELS

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ABSTRACT

The Gas Turbine market for low BTU fuels has become very important in Italy in the last decade mainly due to the chance for the private utilities to sell power to the grid at higher rates according to a national law (CIP6/1992) specifically dealing with recovery fuel use for gas turbine power generation.
Ansaldo Energia has been engaged in three low BTU fuel projects in Italy dealing respectively with IGCC technology and steel mill fuel gas. Each of these plants has its own features which all in all gives a wide range of experiences in development and operation of gas turbine fired with low BTU fuels.
The first project is the ISAB Priolo IGCC plant, whereas two V94.2K manufactured by Ansaldo Energia are in operation burning syngas from residual refinery gasification since 1999. Since the presence of fuel impurities coming from the gasifier a new design phase and a test campaign has been necessary to re-design the syngas burner, originally developed by Siemens PG, in order to overcome this problems. The engines are now successfully operating.
The second project is the Elettra Servola combined cycle plant whereas a V94.2K manufactured by Ansaldo Energia is in operation since 2000 burning a mixture of steel mill gas and natural gas. During the successfully operation some burner design optimisation has been required in order to meet the industrial process modification.
The third project is the ENIPower Ferrera Erbognone IGCC plant is under realisation and the relevant first firing will be expected on next January 2004. The syngas burner test campaign carried out has shown very promising results that have to be confirmed on site.

The paper is showing the combustion concept relevant to the combustion system and is giving an overview about the operating experience achieved by Ansaldo Energia in this field mainly focusing on how the main critical aspects have been faced and overcome.

1. INTRODUCTION

Gas Turbine technology has been applied in the last years mainly in natural gas and fuel oil fire combined cycle plants: for this kind of plants, the efficiency has been increased up to 56-57%. Only in the last decade a different requirement has become important to gas turbine market. A new business area is quickly growing requiring gas turbines be able to offer good performances also by utilising low BTU fuels. This new requirement is strictly related to the commercial success of the IGCC technology, which allows to produce electric power starting from low quality/low cost fuels (as refinery residual oils or low rank coals) with an efficiency higher than the boiler based power plants. Furthermore the gasification technology is coupled to very effective gas cleaning technologies which, in addition to the good performances of the gas turbine concerning the emissions problem, allows to overcome all the environmental problems related to the combustion of such fuels.
This requirement is also met when dealing with the recovery gas carried out by the steel mill process that can also be burnt in a gas turbine instead of a traditional boiler with higher performances and efficiency.
All the fuels coming from these processes, are mainly constituted by a mixture of carbon monoxide, hydrogen, methane and nitrogen.
A direct example of the fuel dealing mentioned above is given by the experiences in this business area gained by Ansaldo Energia, shown by table 1. All these plants are equipped by V94.2K gas turbines manufactured according to Siemens technology and directly supplied by Ansaldo Energia.

	ISAB Priolo	Elettra Servola	EniPower Ferrera

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GT Engine	2 x V94.2K	1 x V94.2K	1 x V94.2K
Main Fuel [as Fuel Thermal Input ratio to the total]	100% tar syngas	51% steel mill gas - 49% natural gas	77% tar syngas-13% natural gas
Back up Fuel	Fuel Oil	Natural Gas	Natural Gas
Net Power	516 MW	180 MW	255 MW
First Firing on Low BTU fuel	August, 1999	November, 2000	June, 2004
EOH on low BTU Fuels	Unit1:41500 Unit2:34100	33850	-

Tab.1. Ansaldo Energia low BTU fuel project supplied (EOH =equivalent operating hours)

All the V94.2K are equipped with silo type combustor and with a proper low BTU fuel burner depending on the fuel features and the requirement of the plant. Thus, for each application it has been necessary to introduce some optimisation of the burner design. The following table provide an overview of the fuel characteristics in order to highlight the wide range of composition of these mixtures, depending on the different feedstock to be gasified or the available by-product gas, the chosen gasification technology, the available added dilutent (N2 and/or steam).
It's worth to be mentioned that, apart the Isab Fuel, all the other indicated are the final result of a blending between the raw recovery gas (steel mill process or syngas), steam and natural gas. This latter is used in order to reach the design thermal input.

	ISAB Priolo	Elettra Case A	Elettra Case B	Elettra Case C	Eni Power Ferrera 1
H2 [%vol.]	31.25	9.03	9.56	1.52	15.71
CO [% vol.]	29.78	16.25	9.61	17.02	28.68
H2O [% vol.]	34.59	5.46	29.55	5.55	48.76
N2 [% vol.]	0.98	40.36	22.42	41.60	0.92
CO2 [% vol.]	3.27	13.61	7.48	13.92	1.59
CH4 [% vol.]	0.13	14.60	20.73	20.08	4.15
C2+ [% vol.]	0.00	0.53	0.54	0.21	0.19
H2/CO [vol/vol]	1.05	0.56	0.99	0.09	0.55
LHV[MJ/nm^3]	7.19	8.67	10.21	9.71	7.15
LHV [MJ/kg]	9.50	7.54	10.54	8.03	8.27
λ[mol/mol$_{fuel}$]	2.91	1.47	2.53	2.39	1.49
λ[kg/kg$_{fuel}$]	4.29	2.50	3.42	2.56	2.29
M$_{fuel}$ at Base Load [kg/s]	47.9	50.4	36.1	47.3	55.6

Tab.2 Fuel properties

2. COMBUSTION SYSTEM REQUIREMENT

2.1 Low BTU fuel analysis

The analysis of a unknown kind of fuel is possible considering the following parameters:

- low heating value
- adiabatic flame temperature
- laminar flame velocity

In the following pictures, the calculation result concerning the laminar flame velocity and adiabatic flame temperature at the relevant actual engine conditions are showed. While the adiabatic flame temperature is a basic parameter for the evaluation of the NOx emissions, the laminar flame velocity couple with the CFD analysis gives indication of the blow off stability and the burner overheating tendency.

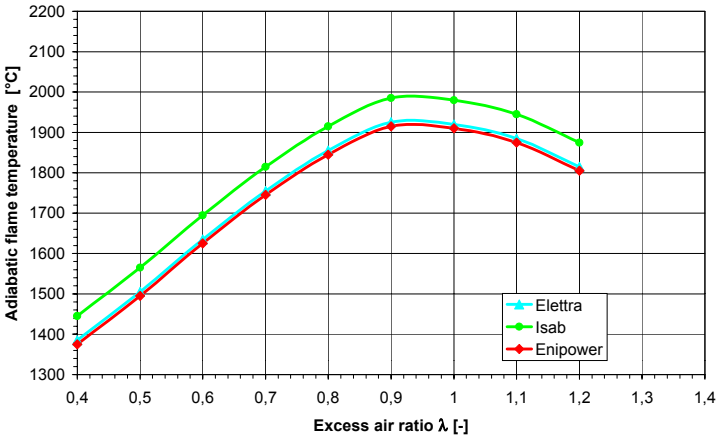


Fig.1 Comparison of calculated adiabatic flame temperature

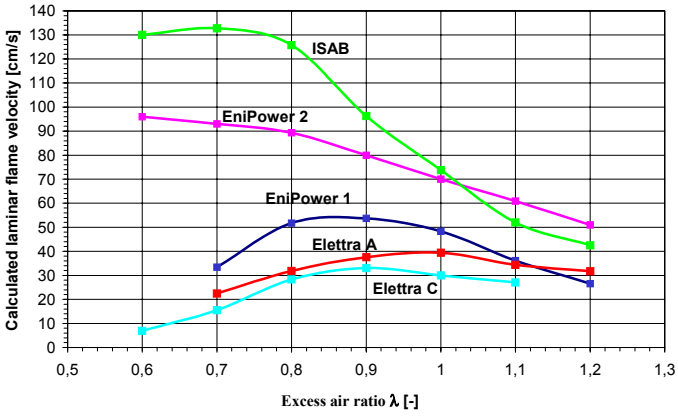


Fig.2. Comparison of calculated laminar flame velocity

The main differences are related to the different flame speed features. On fig. 2 a comparison among Isab, EniPower and Elettra low BTU fuel has been shown. These flame velocities have been calculated using the Premix Software of the Chemkin Code fed with the actual boundary conditions of each relevant engine and with the GRI natural gas reaction mechanism. The figures presented into the x axis refer to the local air fuel ratio compared to the stoichiometric one. As you can notice, the relevant flame velocity figures for each kind of fuel are quite different. Isab has got a single curve with higher peak value, whilst Elettra fuels reported very low peak value, also lower than the standard natural gas. Finally, the results

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carried out for EniPower fuels showed the wider figure variation. This means that for each kind of fuel a sort of optimisation of the standard low BTU must be performed including a CFD analysis and a burner test campaign in order to finalise the proper burner design.

2.2 Burner design

The burner design experienced on the three engines mentioned on the table 1, is based on the syngas burner development for the V94.2 machine performed by Siemens PG at both Demkolec in Buggenum/Netherlands and later jointly with Ansaldo Energia, at ISAB in Priolo, Italy. Both Demkolec and Isab burner have already demonstrated several thousand hours of successful operation with syngas. As consequence of the different composition and the variability of Elettra steel mill gas, the syngas nozzle was re-designed and tested in two different test campaigns at Ansaldo Combustion Centre and ENEL laboratories in Italy. The same procedure has been used also for the EniPower Project

A sketch of the complete burner is presented on figure 3. The main features of the burner are summarised below.

The Ansaldo Energia low BTU fuel burner is in general capable to operate with natural gas, diesel oil as well as low BTU fuel in diffusion mode. For EniPower and Elettra project the diffusion oil lance, usually located at the burner centreline, has been substituted by a dummy, since backup fuel is natural gas. The combustion air feeds the burner via two concentric swirlers, whose main function is to generate the correct hot gas re-circulation which stabilises the flame in free space downstream of the burner.

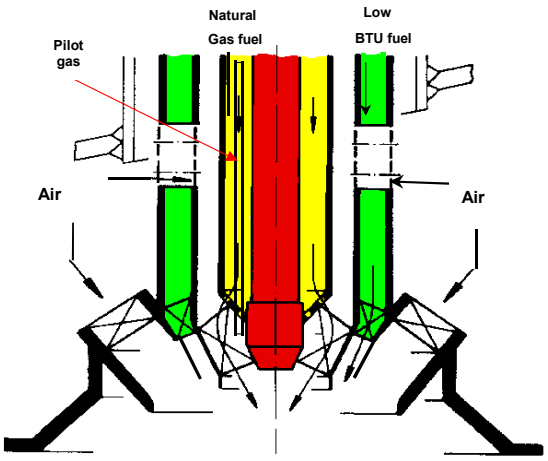


Fig.3. V94.2 K low BTU fuel burner sketch

A minor amount of the combustion air feeds the inner air passage and enters the combustion chamber through an axial swirler. The main amount of the combustion air passes a diagonal swirler that is the outer passage of the burner. Ignition gas is fed through the diffusion gas passage located concentrically around the dummy. The ignition gas is injected into the axial air flow in front of the axial swirler. Low BTU fuel is fed through an annular passage between the axial and diagonal swirler air passages. Because of the high mass flow rates of the low BTU gas, the fuel passage has a much larger cross section than a corresponding nozzle for natural gas. More over according to the fuel characteristics derived by the plant specification, the pressure drop and the swirl number have been adapted in order to optimise the combustion.

2.3 Fuel system design

As already mentioned, the fuel system for the low BTU engine has to supply much higher flow rates to the burners than for the standard engine. The fuel system consist therefore of a pipe work with large diameters including the use of control and stop valves, and must include additional mixing in order to get the final blend of recovery gas, natural gas and occasionally steam. According to the experience achieved by Siemens and Ansaldo on Priolo and Buggenum plant, since the presence of toxic and explosive components into the blending, the fuel system must meet a very high safety standards. Thus all flanges and joints between the burners and the connection point to the skids are welded. A sketch of the EniPower fuel system is shown in fig. 4: the aim of this sketch is giving an example of the complexity of the fuel system if compared to the natural gas one. In fact the low BTU fuel system arrangement is including, the further following lines:

- raw BTU fuel line
- natural gas integration line
- steam line for NOx abatement
- Low BTU fuel blending line to the gas turbine
- nitrogen line for purging
- flare lines

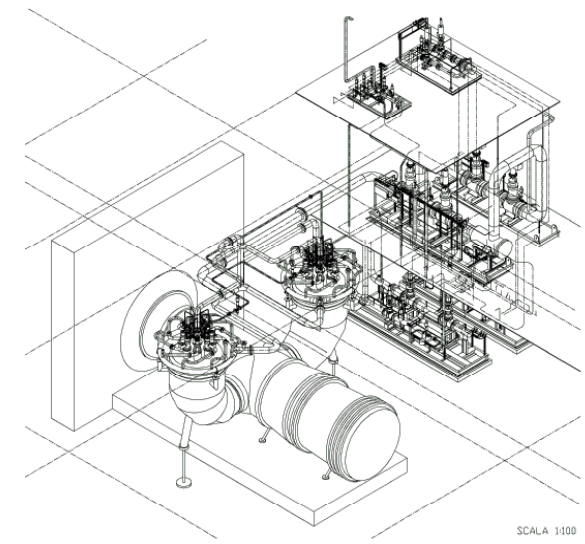


Fig.4. V94.2 K low BTU fuel feeding system sketch

According to the gas turbine working conditions, the gas turbine loading is performed by using the back up fuel, mainly for safety reasons. Thus, a procedure for fuel switch over from back up fuel to the main fuel is performed in a fully automatic control. More over if a blending between two or three streams is required (i.e. natural, gas, main fuel and steam, a mixing procedure is performed so that before entering the combustor at the change over, the blending features are monitored and analysed on line. The blending is sent to the flare until these

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features are not matching the design figures: once the matching has been achieved the changeover procedure can start.

Finally, a purging procedure before any low BTU fuel partial or full load working condition must be applied with nitrogen or steam in order to avoid possible risks of explosion due to the reactivity of the fuel when exposed to mixing with air.

3. GAS TURBINE OPERATING EXPERIENCES

All the gas turbine fuelled by low BTU fuel, mentioned in this paper, are running successfully according to the customer requirements. Performance and efficiency are higher than expected and the emissions are well below the contractual value. In the table 3 the guaranteed and actual measured emissions are reported. Please notice that, at the moment, no data are available for EniPower project since the first firing will occur later on. The figures reported for Elettra concern only what guaranteed.

	Isab	Elettra A	Elettra B	EniPower 1-2
Guaranteed NOx [ppmdry@15°2]	75	35	35	25
Measured NOx [ppmdry@15°2]	30	26	23	-

Table 3.

3.1 Elettra Servola Operating experience

The end of demonstration period of the ELETTRA GLT Servola combined cycle plant, and the start of its commercial operation gave us the opportunity to present a review of the operating experience of the Ansaldo V94.2K gas turbine fuelled by the steel mill gas – natural gas blending. Generally, all the design guidelines adopted at the beginning of this project has been confirmed by the results carried out on site in all the operating condition required and performed [11].

Up to date, the engine has been running low BTU fuel for more than 20000 hours with no problem occurring.

At the beginning of 2002, the customer was forced to change the fuel composition according to the new steel mill process requirements since a blast furnace had to stop definitely. Thus Ansaldo Energia was asked to evaluate the possible consequences on the gas turbine working conditions.

The first consequence, was that the fuel features were lying beyond the contractual limits: thus Ansaldo Energia was asked to proceed on a new design study in order to verify the possibility to burn such a kind of mixture with the actual low BTU burner or if necessary to proceed with a new burner design optimisation.

The new analysis considered mainly the following parameters to be compared with tyhe actual ones:

- dilution ratio of the raw fuel
- fuel pressure drop
- fuel swirl

The new cases are reported in the table 4: there's not such a difference compared with the original blending features as reported in table 1. But, looking deeper, the higher H2 content could give an indication of problems related to overheating also if the H2 to CO ratio staying within the design range. Therefore the relevant flame velocities have been calculated using the Premix Software of the Chemkin Code fed with the actual boundary conditions of each relevant engine and with the GRI natural gas reaction mechanism.

	Elettra Case A1	Elettra Case B1	Elettra Case C1	Elettra Case C2
H2 [%vol.]	11.15	10.61	10.88	13.11
CO [% vol.]	15.55	16.31	15.69	13.89
H2O [% vol.]	7.64	7.10	1.80	10.95
N2 [% vol.]	35.62	36.16	40.43	35.21
CO2 [% vol.]	12.03	12.21	13.64	11.92
CH4 [% vol.]	17.40	16.96	16.91	14.02
C2+ [% vol.]	0.61	0.64	0.64	0.73
H2/CO [vol/vol]	0.72	0.65	0.69	0.94
LHV[MJ/nm^3]	9.82	9.70	9.63	8.73
LHV [MJ/kg]	9.03	8.82	8.51	8.19
λ[mol/mol$_{fuel}$]	2.39	2.35	2.34	2.11
λ[kg/kg$_{fuel}$]	2.83	2.76	2.67	2.55
M$_{fuel}$ at max. load achievable [kg/s]	38.72	41.49	42.18	31.67

Table 4

The results, reported on figure 5, have been compared to the actual ones.

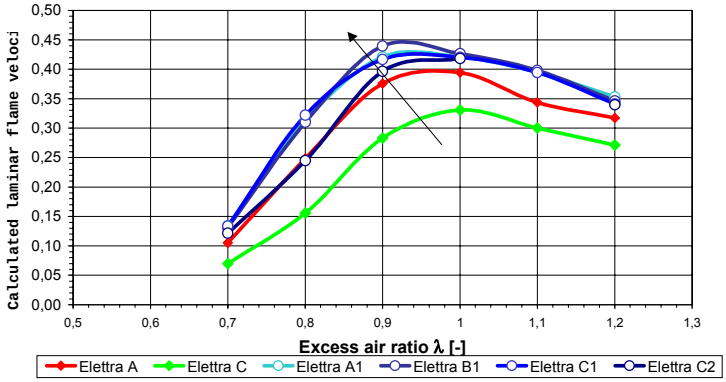


Fig.5. Comparison of calculated laminar flame velocity relevant to new fuel compositions

This further investigation on the new fuel flame velocity, gave the indication that an increasing of the maximum peak (up to 12% if compared to design value), coupled with a decreasing of the relevant air excess ratio (under stoichiometric conditions), could lead to a possible flame backward thus getting higher burner metal tip temperature

The increasing rate cannot be considered in principle so different,but the long term effects cannot be considered negligible. In order to get further data to drive the final decision on the possible modifications to be applied on site, it has been decided to verify first the burner geometry performing test on single burner rig at full engine conditions.

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These tests have been performed at ENEL Experimental Area in Sesta (Italy) and mainly concerned the following points:

1) burner metal tip temperature
2) Flame stability under all working conditions of the machine
3) NOx emissions (steam content verification)

A full scale burner was tested due to the inaccuracies regarding the validity of tests performed by scaled burners. The combustion tests were performed with the four steel mill gases previously mentioned in table 4.

During all test operation periods, the dried exhaust gas was online analysed for O2 and CO2 to have an independent control of the adjusted flow rates (air excess ratios). Only test periods for which the adjusted and measured air and fuel mass flows correlated correctly with the O2 and CO2 based calculated air excess ratios were used for evaluation.

The burner was instrumented with further thermocouples at the tip in order to monitor the eventual flame backward position. Also a flame monitoring via an optical window was available in order to verify an eventual change of the flame shape. On the figure 6, two cases (the more and the less severe) are reported.

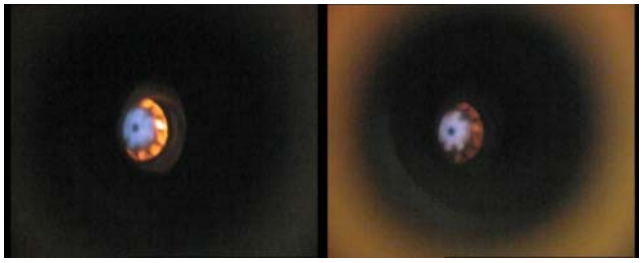


Fig. 6. Flame shape case A1 (left) and C2 (right)

Generally, the new working condition asked by the Customer, caused a not negligible flame backward. The metal tip temperature difference with respect to the compressor outlet air temperature is increasing from -20 °C up to a maximum of 40°C: this figure is not dangerous for the engine but it tends to approach the threshold value.

Anyway, since the flame shape was well balanced and the burner performances, especially in terms of emissions, was comparable to the design figures it was decided to maintain the same burner geometry.

A further investigation was performed, analysing the possible decay of the low BTU fuel burner in terms of material mechanical characteristics on a long term period: the results gave a reduction of the safety margins estimated nearby 20-25%. Therefore the low BTU fuel burner material was changed from X6CrNiMoTi 17-12-2 to Inconel 617.

The validation on a full engine was performed during a major overhaul outage after the new set of burner was mounted on the engine. Since the new steel mill plant boundary conditions, a new re-commissioning phase was performed.

The functional test performed on site showed a very variable composition due the unstable process conditions depending not only by the state of the blast furnace or the coke oven but also on the feedstock applied.

The main targets of the functional test were:

a) Burner temperature overheating verification
b) Dilution Steam consumption optimisation
c) Gas Turbine performance verification

Concerning the first point, the results showed as the same metal tip temperature as carried out during the test campaign. This could allow to run the engine in safety conditions also due to the low BTU material change.

Second, due to the high variability of the steel mill process, Ansaldo was asked to provide a modification of the dilution ratio calculated. At that moment, this was performed taking into account the low calorific value of the blending measured by instrumentation on line (calorimeter and gas chromatograph), but sometimes the steam injected was quite high with respect to the emission measured at the stack.

Thus, since the optimisation of the dilution steam was a customer requirement and taking into account the test results ion the engine, it was allow the control operator to manually perform a bias regulation. Thus, it was given the customer the chance to further increasing or decreasing the steam content within a defined range (±3 kg/s), according to the state of the steel mill process indicated on the operator screen.

Generally, in all the cases performed, the NOx and CO emissions were below the guaranteed value.

Concerning the gas turbine and the relevant combined cycle performances, it has been worth to be noticed that generally, these ones are confirming as the same figure as for the design working conditions as reported on table 5. Please notice that for the GT efficiency evaluation the power of the steel mill recovery gas compressor driven by the gas turbine must be taken into account.

	Maximum Thermal Input [MW_t]	GT Power [MW_e]	GT Net Efficiency [%]	Plant net Efficiency [%]
Elettra A	380	111.2	34.4	44.0
Elettra B	380	110.6	34.0	43.7
Elettra A1	349	95	32.9	43
Elettra B1	366	102	33.3	43.5
Elettra C1	359	98	32.8	43.5
Elettra C2	259	57	29.6	35

Table 5.

Due to the conclusions carried for each of the target mentioned above, Ansaldo allowed the customer to run the power plant according to the new boundary conditions thus including these latter within the guarantee requirements.

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Fig.7. Burner detail

The further inspections at the gas turbine, after the re-commissioning period, showed no overheating traces on to the burner thus confirming the good performances of the low BTU fuel burner as it reported on fig. 7, where you can see a burner detail after more than 10000 EOH (equivalent operating hours)is shown.

3.2 Isab Priolo Operating experience

At the site of ISAB Priolo, in Sicily, two GT V94.2K delivered by Ansaldo Energia are in operation burning syngas from residual refinery gasification since about 4 years.

The general performances of these machines are very satisfactory, but an unexpected problem occurred after the first year of operation.

Due to the relevant content of H2 in the syngas composition (tab.2) , each burner is suited of two thermocouples, whose signals are connected to the control system in order to protect the machine in case of overheating. At the beginning of the second year of operation some of these thermocouples started to measure sudden temperature increase above the allowed limit with consequent change over to back up fuel operated by the control system.

No relationship between these overheating and the process parameters has been found.

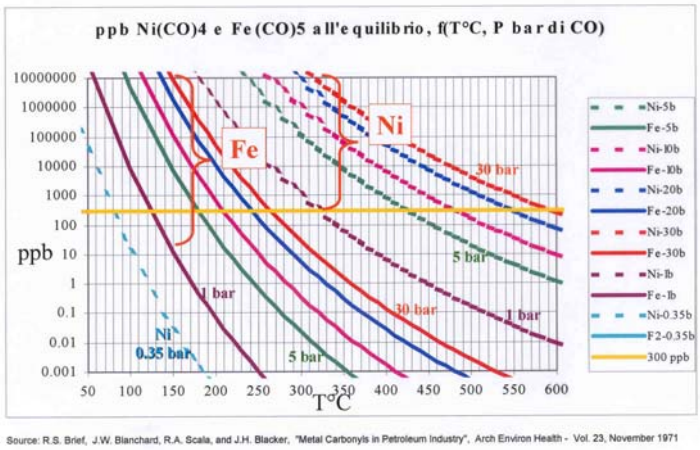


Fig. 8 Burner Overheating

The visual inspection of the combustion chamber detected large amount of deposit on the burners and on the first turbine stage. Additionally some burners showed indications of partial combustion on the axial swirler, clearly related to the geometry of the syngas nozzle (fig. 8).

These deposits had really hard consistency so that a mechanical brushing have been necessary in order to clean up and restoring the burners. It has been demonstrated that the deposits removing is very effective to avoid the overheating problem: after this operation the machine can be operated without any problem, but after 3-4 weeks the temperature on some burners increases again due to deposits formation. Some samples of the deposit has been collected both from the burners and from the first stage blades. The chemical analysis detected high amount of Nickel on both samples without finding other kind of chemical species featuring the alloy of burner material: thus, this is coming form another source.

It was found that a chemical compound containing Nickel (Ni(CO)4) is produced during the gasification process and is present at small amount (ppb order of magnitude) in the Fig.9 Carbonyls equilibrium curves



syngas composition. This compound is a gas that becomes unstable at temperature higher than about 350°C, depending on the actual concentration in the syngas – fig. 9. As the instability temperature is close to the typical air temperature on burner outlet, it's most probably to find some metallic Nickel deposits on this area. When the deposit thickness is getting higher, the local aerodynamics starts to be modified: the anticipated mixing between fuel and air occurs and consequently flame front can shift closer to the burners causing overheating. Only the cleaning operation of the burners is necessary to come back in safe conditions. As the overheating has been localised in a very small area of the burner, it has been noticed a thermal stress and consequent cracks. Finally this phenomenon was dangerous for the plant reliability for two reason at least:

- burner mechanical damage at long term
- gas turbine outages for cleaning operation (loss of power production).

First, removal systems of these impurities has been investigated by the customer without any success: finally Ansaldo Energia has been required to develop a modification of the combustion system able to operate in a reliable way

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also with Nickel-carbonyl still present in the syngas composition. In order to overcome this matter, Ansaldo Energia engineers decided to develop a new syngas nozzle design. A CFD model of the burner near-field has been performed and parametric evaluations of different geometry have been tested. On the basis of numerical simulation results, experimental nozzles have been manufactured and tested at atmospheric conditions at the Combustion Test Facility of Ansaldo Energia.

Since the laboratory tests good results, some nozzles have been decided to be installed on the actual machine despite of the original ones on site in order to get a performance comparison. The new nozzles employed operated successfully for some months. No overheating problems and no damages have occurred on this burners, whilst the previous design burners still required to stop the machine each month due to high temperature consequent to Nickel deposit on axial swirlers.

In April 2003 it has been decided that the burners of both the machines in ISAB Priolo to be suited with the new design syngas nozzles. In order to allow a better data analysis, both the machines have been monitored by on line Acquisition System TVA by Ansaldo Energia.

The most important findings after about 6 months operation may be summarised as follows:

- Burner tip temperature: no sudden increase of temperature has been observed. A very smooth temperature increase is due to gradual deposits accumulation (fig.10)

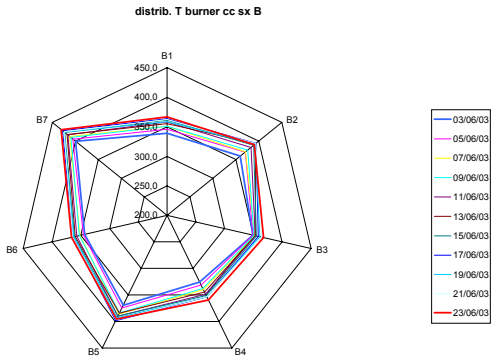


Fig. 10 - Burner Temperature distribution

- Exhaust temperature distribution: no relevant changes, but a slight improvement on the spread (fig.10)

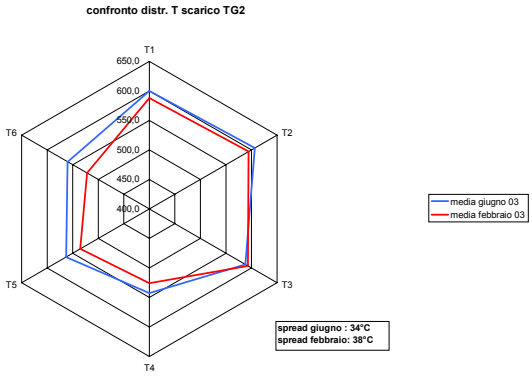


Fig. 11 – Exhaust Temperature distribution

- NOx and CO emissions: no difference in CO emissions, but slightly relevant increase of NOx was detected due to the design requirement to avoid premixing of syngas and air. Any case the guaranteed value is met without problem and it is possible to improve the design in order to decrease also NOx
- Thermoacustic stability: no acustic instability has been recorded at any operating condition.

Also the inspection performed after about five months of syngas operation confirmed the good performances of the new nozzles. Nickel deposit was still not fully avoided (fig.12) since it's still present in a smaller area of the burner if compared to the deposit on the original nozzle design. Anyway the goal of the new design has been mostly reached since the outages number has been heavily decreased and damage of the burners due to overheating has been avoided.



Fig.12 – Nickel deposits after 5 months

3.3 EniPower Ferrera Experience

On January 2001, Ansaldo Energia has been commissioned by EniPower, the Eni group company responsible for the generation and sale of electric power, to build 10 combined cycles for implementation in 4 industrial areas earmarked for chemicals production.

Within this supply, the only V94.2 K power plant burning syngas will be the first one in Italy to operate without taking into account the high benefits once available according to the national law (CIP6/1992). This law, specifically dealing with

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recovery fuel usage (alternative to natural gas) for power generation by private utilities, has been repealed since two years.
The low BTU fuel burner has been designed taking into account all the fuel characteristics deviation from the past experience carried out for Isab Priolo and Elettra Servola projects. According to these, the burner design has remained mainly unchanged but the swirl has been optimised due to the different flame velocity calculated (see fig. 2 for comparison).
Nevertheless these slight modifications, the burner has been tested both at atmospheric and full engine conditions since the NOx requirements for this project are more stringent (NOx below 25 ppm). On pictures 13 and 14 you can see the test burner and the ENEL pressurised rig used for the test campaign.
During these test the main aspect to be investigated have been:

a) Minimum load when feeding the gas turbine with syngas
b) NOx emission from 60% load up to base load
c) Change over form natural gas to syngas and vice versa.

Concerning the first item, the test confirmed the possibility to run the engine with the minimum syngas flow rate required (30% with respect to the base load condition) corresponding to nearly idle condition. It has also confirmed that eventual natural gas integration in order to get the maximum power output is allowed starting from 50% load.
d)



Fig. 13. Test burner



Fig. 14. High Pressure Test Rig

Concerning the second item, it has been confirmed that the NOx emission will not be exceeded and that the further decreasing steam dilution rate (10% saving) must be confirmed on functional test on the engine on site. The CO level emissions measured was negligible:
The issue c) has been tested simulating at high pressure the fuel change over procedure: according to the test results carried out , the minimum load for the change over has been set to 35% load.
Finally, as a general overview of the results carried out it has been assumed that the gas turbine will be running as follows:

a) Ignition by natural gas
b) Loading up to 36% load: natural gas dry (without steam dilution)
c) Change over at 36% load by syngas diluted with steam;
d) Loading from 36% up to 50% load by syngas diluted with steam;
e) Loading from 50% up to 100% load by syngas diluted with steam and integrated with natural gas.

At the moment the engine is ready on site and the commissioning phase will start on January 2004 by natural gas. Due to the gasifier project delay the syngas won't be available until the end of 2005, thus the engine will be working until that date with natural gas-steam blending.

4. CONCLUSIONS.

The paper is showing the combustion concept relevant to the combustion system and is giving an overview about the operating experience achieved by Ansaldo Energia in this field mainly focusing on how the main critical aspects have been faced and overcome.

Due to the very interesting market in Italy for low BTU fuels applications for Gas Turbines, Ansaldo Energia gained a deep experience dealing with the specific requirements of these kind of plants.

Since each plant requirements and each syngas composition is different, it's a usual procedure that the combustion system has to be checked and optimised for each project.

This requires high combustion engineering flexibility and specific syngas testing capability. The successful experiences described in the present paper show that both the above conditions are actually met by Ansaldo Energia.

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