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TKS CSA

Special Project Collection

The CCPP can convert 4.7 million tonnes per annum of high-pressure steam from the coking plant and an additional 20 million GJ/year thermal energy from the low-calorific BFG into electricity for both the steel complex and Brazil's national grid

Brazil steel making complex raises the bar for CCPPs utilizing waste gases

Blast furnace gas from a new steel making plant in Brazil will be firing a state-of-the-art on-site combined-cycle power plant (CCPP) when production begins at the facility, located in Rio de Janeiro's industrial district of Santa Cruz. High efficiency and flexibility of operation were key considerations in opting for the Alstom power plant solution.

A new 480 MWnet combined-cycle power plant operating with blast furnace gas (BFG) produced by the blast furnace, and natural gas as the start-up fuel, is been engineered, constructed and commissioned by Alstom under a full engineering, procurement and construction (EPC) contract for ThyssenKrupp Steel AG in Brazil. This project marks a significant step forward in the provision of power for steel making plants. Aside from supplying 200 MW of electricity to the steel complex, the power plant provides an additional 280 MW to be exported to the Brazilian grid.

The new and fully integrated steel making complex in Santa Cruz will bring production to a region which has traditionally exported the majority of its ore. By strengthening the steel making chain, ThyssenKrupp Companhia Siderúrgica do Altântico (TKS CSA) aims to boost high value exports to areas such as the United States and Europe. The facility is the biggest industrial investment in Brazil in the past ten years and is also the first major steel mill to be built in the country since the mid-1980s.

The investment project is central to ThyssenKrupp's growth strategy for premium carbon flat steel in Europe and North America. After start-up, the plant will produce 5 million tonnes of high-quality, low-cost slabs. Some 3 million tonnes will be supplied to a processing plant under construction near Mobile in Alabama, while a further 2 million tonnes will go to ThyssenKrupp's plants in Germany, where it will be processed for customers in Europe.

The CCPP is central to the project, and is tipped to set a blueprint for steel works across the globe, notably in Asia. So believes Christian Bohtz, Alstom's product manager for industrial power solutions.

"Asia represents a big market for the development of this type of technology. And we've shown with TKS CSA that we have the products to bring high efficiency to the steel making process with integrated power production."

The key, says Bohtz, is in the utilization of low-calorific BFG, which can be used as a mono fuel in the Alstom GT11N2 LBtu, a specially designed gas turbine for this purpose. "It is the only gas turbine capable of doing this," says Bohtz. "Other gas turbines on the market require feed gases with significantly higher calorific value, usually achieved by mixing BFG with natural gas or coke oven gas."

"What we've done at TKS CSA is to take and utilize the BFG; this was a requirement of the project – to minimize gas flaring – and additionally we have adapted the steam turbine configuration to take the steam produced by the coking plant and steel mill to boost the overall power output.

"Our Plant Integrator™ approach also means we're prepared to adapt our reference or standard plants specifically to accommodate customers' needs. We can adapt the components to achieve and optimize a solution. That's one of our strengths."

The TKS CSA plant represents what Bohtz describes as a "winning solution," which could be adopted elsewhere to considerable effect, as industrial operations resulting in waste gases as by-products are interested in improving their overall heat balance in order to reduce their electricity and energy consumption.

The TKS CSA low-heat CCPP has been specifically tailored to the demands and the specific site conditions of the integrated steel plant. The plant capitalizes on the use of cheap by-products from the steel mill – BFG and steam produced by the coking plant – to produce electric power, covering the auxiliary load of the facility itself, while selling a significant surplus to the Brazilian public grid. It is an attractive economic model, Bohtz stresses.

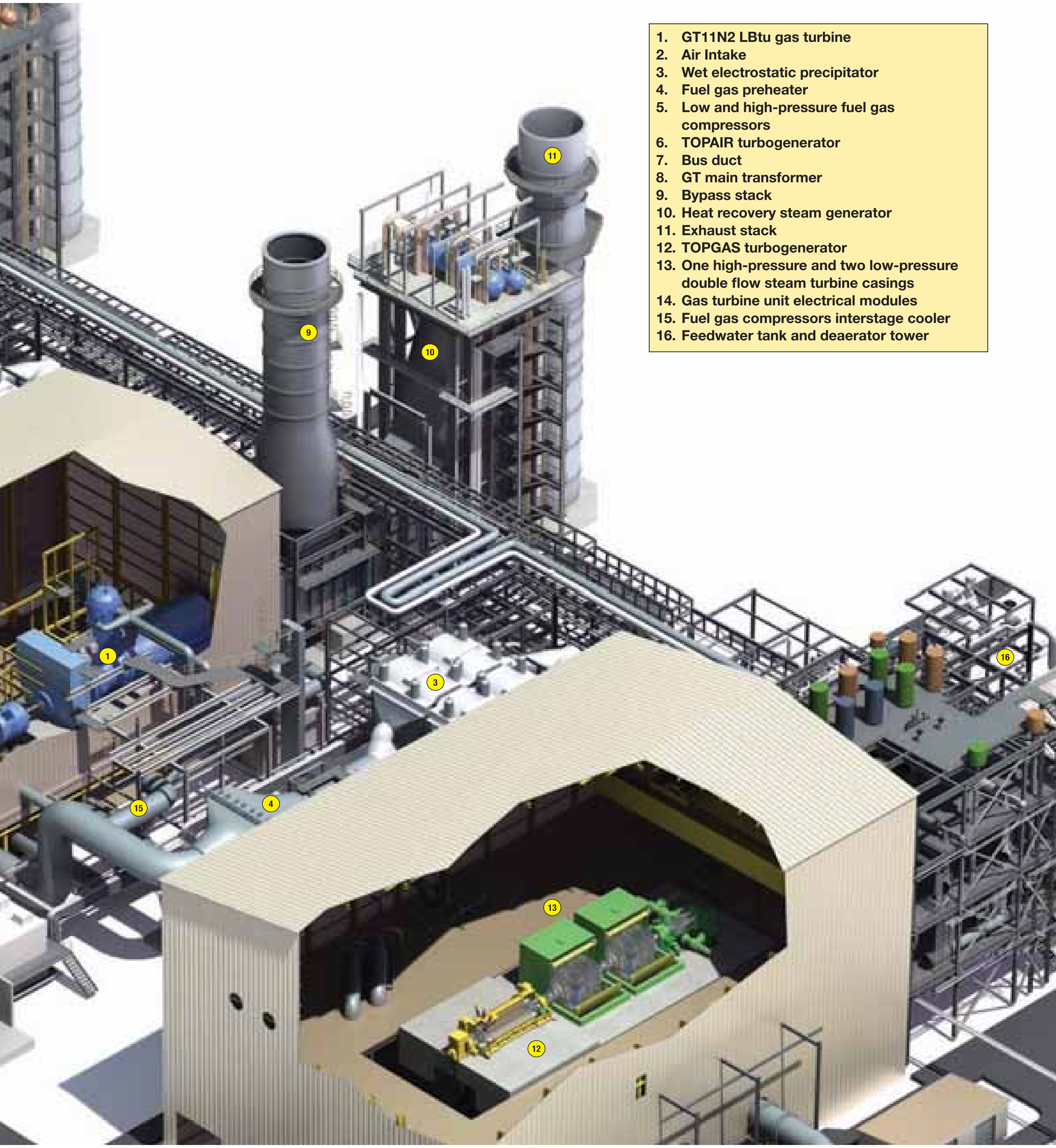
MAXIMIZING OPERATIONAL FLEXIBILITY

Flexibility of operation has been uppermost in the customer's requirements from the inception of the project. To achieve this aim, the overall concept comprises two independent gas turbine units, each with an availability greater than 92 per cent.

The low heat (LBtu) CCPP is designed to have an efficiency exceeding 45 per cent. In addition to the 20 PJ/year of low-calorific BFG, the plant is designed to use 4.7 million tonnes/year of high-pressure steam (89 bar, at 520 °C at the CCPP boundary) produced by the coking plant.

The TKS CSA plant presents a huge potential for saving natural gas. Its two blast furnaces will produce a staggering 1.2 million m^3/h of BFG, of which 450 000 m^3/h is consumed in cowpers, leaving 740 000 m^3/h available for use in the power plant itself.

A gas holder storage facility, with a capacity of 100 000 m^3, enables the gas system to run at a constant pressure of 130 mbar. The amount of gas


1. GT11N2 LBtu gas turbine
2. Air Intake
3. Wet electrostatic precipitator
4. Fuel gas preheater
5. Low and high-pressure fuel gas compressors
6. TOPAIR turbogenerator
7. Bus duct
8. GT main transformer
9. Bypass stack
10. Heat recovery steam generator
11. Exhaust stack
12. TOPGAS turbogenerator
13. One high-pressure and two low-pressure double flow steam turbine casings
14. Gas turbine unit electrical modules
15. Fuel gas compressors interstage cooler
16. Feedwater tank and deaerator tower
1
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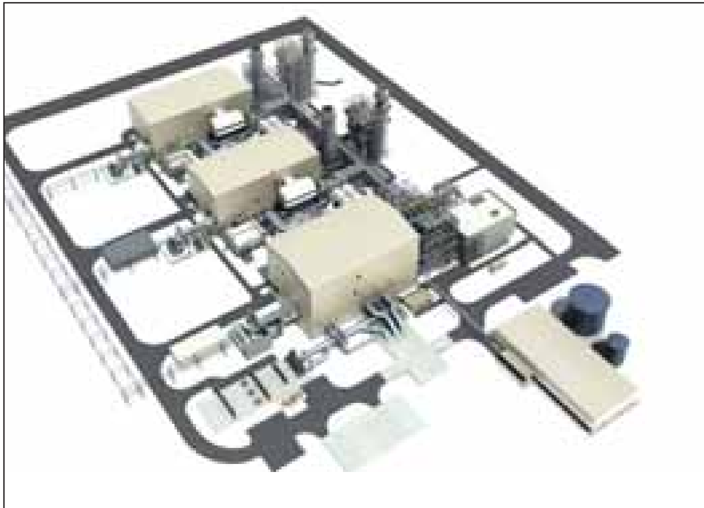

Availability of each unit of the CCPP had to be greater than 92 per cent

BASIC TECHNICAL DATA	
Configuration	multi-shaft, two gas turbines plus one condensing steam turbine
Power plant installed capacity	480 MWnet
Fuel	blast furnace gas, 353 MJ/s at each gas turbine
HP steam import from coking plant	551 t/h @ 88 bar/522 °C
LP steam import from steel mill	20 t/h @ 16 bar/240 °C
Feedwater return to the coking plant	579 m^3/h @ 18 bar/153 °C
Condensate return to the steel mill	110 m^3/h @ 25 bar/37 °C
Emissions @15%O_2, dry	
NOx:	25 ppmv
CO:	10 ppmv
Particulate:	10 mg/Nm^3
Design ambient conditions	
Temperature:	25 °C
Humidity:	80%
Pressure:	1.013 bar

generated can vary greatly in a very short time – up to 100 000 m^3/min – so the plant has to be capable of handling this or an unwanted over-pressure causes the gas to trigger safety valves, upon which it is flared.

Though not an entirely new technology, TKS CSA represents a development in scale for BFG fired CCPPs. "Normally integrated steel and power plant arrangements consist of units that have a conventional boiler and steam turbine system. In these situations the BFG fired boiler produces high-pressure steam, and a multi-casing steam turbine is used for the purposes of electricity generation," explains Eduardo Sá, Alstom project engineering manager.

"At TKS CSA, most important is the use of the BFG which is the residual gas of the blast furnace as fuel in the gas turbine, running in combined-cycle. With that we gain additional performance when compared to a conventional plant.

"The result is that the KA11N2-2 LBtu combined-cycle plant offers a much better efficiency compared to boiler-based BFG solutions. Due to the ability to burn pure BFG, no natural gas or expensively cleaned coke oven gas is required to be mixed with the BFG, resulting in lower operating costs.

"With the operation range of 0 to 100 per cent gas turbine electrical load on BFG, the plant is very flexible, in particular with the optimal integration into the steel plant. Additionally, environmental benefits are derived from higher efficiency, lower NOx (nitrogen oxides) and lower CO (carbon monoxide) emissions.

"If you were to simply flare the BFG or use it in a conventional boiler the emissions would be much higher. The gas turbines, each consume some 353 kJ/s of BFG, significantly reducing the CO and NOx emissions.

"In addition, the many interfaces we have with the steel plant promote other savings. The feedwater, for example, is returned to the coking plant deaerated and preheated. The integrated water cycle accounts for 551 tonnes/h.

"Then there's the issue of flexibility. By having two gas turbines, the client has the option to operate plant redundancy. He can, for example, stand down one of the gas turbines if steel demand is not so high, while another operates at full load. Also one gas turbine can be undergoing maintenance while the other continues to utilize BFG."

There are benefits to be gained also, says Sá, should there be the need to undertake maintenance on the steam turbine. "If there is maintenance on the water/steam cycle area of the CCPP, the coking plant can be kept at full operation and the power plant will condense the steam produced by the coking plant in the CCPP dump condenser and return the feedwater to the coking plant. In this way the steel complex can operate as demand requires. In other words, the power plant will not limit the production of steel in any way. Similarly, any fluctuation in the production of steel will not affect the power plant's operations."

Sá says Alstom's unique solution to firing pure BFG is in the design of the burner to cope with very low heating (calorific) value feedstock. Prior to feeding to the gas turbine combustor the BFG is cleaned in an electrostatic precipitator to reduce the dust content of the delivered BFG and therefore reduce the particulates emissions at the exhaust outlet stack. It is then compressed in the gas compressor, which is located on the same shaft as the gas turbine-generator compound.

BFG BECOMES A VALUABLE RESOURCE

TKS CSA gave the notice to proceed with the new greenfield, captive CCPP plant in November 2006. The power plant will be constructed in two phases – simple cycle and then combined-cycle – to allow power generation from an early stage. It is the first Alstom low Btu fuel fired plant in Brazil.

Alstom's scope of responsibility extends to a full EPC turnkey contract, as well as the commissioning of the complete KA11N2-2 LBtu combined-cycle plant and its related balance of plant and civil works. TKS CSA is responsible for supplying the fuel gas (natural gas for start-up and BFG for operation) and 551 tonnes/h of steam (180 MWe) from the steel plant's coke oven boilers.

The decision to select Alstom to undertake the project was, says ThyssenKrupp, based on a detailed analysis, and specifically focused on the company's experience with firing BFG. The company's Plant Integrator approach also played a significant part in securing the contract. Alstom was able to demonstrate that its KA11N2 LBtu power plant could burn BFG at a higher efficiency that alternative, conventional BFG boilers.

The CCPP is built around the GT11N2 LBtu gas turbine, which has more than ten years of operating experience in steel plant application. Fired exclusively by BFG, the first plant in Bao Shan, China has achieved an efficiency of 46 per cent and a power output of 154 MWe. Experience has shown that highly efficient combustion leads to permanent single digit NOx and CO emissions. A second unit went into operation in Mizushima, Japan, in 2001 and the two units have between them accumulated more than 130 000 operating hours firing pure BFG.

Bohtz, along with two colleagues – Bernard Tripod and Kurt Rieder – presented a paper on the project at the POWER-GEN India and Central Asia conference last April, in Mumbai. Bohtz highlights some of the trio's key points about the technology employed.

"A steel plant produces several waste gases that can be utilized for power generation instead of flaring. BFG, coke oven gas and converter gas from basic oxygen steel making (called LD or BOS gas) are among them. Typically 40 MWe to 50 MWe can be produced per million tonnes of annual steel making capacity."

This represents not just a waste by-product, says Bohtz, but a valuable resource which can offset the need for natural gas. "Produced in large quantities, BFG has a low calorific value – in the range of 2000 kJ/kg to 2500 kJ/kg – but with a high dust content. Traditionally BFG has not been used as the main fuel for a gas turbine, but rather mixed with fuels with higher calorific value, such as heavy oil, fuel oil or coke oven gas, and fired in specially designed boilers."

Alstom's approach has instead been that of striving to achieve an economical and heat balance optimization, enabling BFG to be introduced as the main fuel in CCPPs. This is in spite of the fact that BFG has the lowest heating value that can still be burnt in a gas turbine.

Coke oven gas, produced from coke production in integrated steel plants, is often used as a replacement for natural gas because it has a heating value up to 40 000 kJ/kg. But it is not always available at steel plants. At any rate, its high dust, tar and soot content mean it must be extensively cleaned, and this required cleaning can make it as expensive as natural gas. However, if required, coke oven gas can be used in a mixture with LBtu gas in the KA11N2 LBtu plant, the maximum proportion of coke oven gas by volume being 11 per cent when mixed with LBtu gases having a lower calorific value – below 2500 kJ/kg. BOS, or converter gas, can also be mixed with BFG and burned in a KA11N2 LBtu.

HIGH EFFICIENCY AND HIGH AVAILABILITY

As the TKS CSA plant is constructed on a greenfield site, the project lends itself to supporting an optimized plant configuration. The location affords good boundary conditions and the security of a ready supply of high-quality iron ore. TKS CSA conforms to the fully integrated steel plant concept, being characterized by the interconnection of many different energy systems.

"In an optimized site infrastructure, the power plant needs to be customized and integrated into the steel plant, as the power plant has a great impact on the energy efficiency and profitability of the whole steel works," explains Bohtz.

GAS TURBINES	
Number	2
Type	GT11N2 LBtu
Main fuel	blast furnace gas
Start-up fuel	natural gas

STEAM TURBINE	
Number	One high-pressure and two low-pressure double flow steam turbine casings
Type	VLA-HDC160/G120-ZLN-ND34Bu-AGG
High pressure steam	
Flow:	949 t/h (551 t/h from coking plant and 199 t/h from each HRSG)
Pressure:	86 bar
Temperature:	518 °C
Low pressure steam	
Flow:	19 t/h
Pressure:	5.9 bar
Temperature:	246 °C

HEAT RECOVERY STEAM GENERATORS	
Number	2
Type	dual pressure, with drums, natural circulation and by-pass stack
Stack height	40 metres

The brief represented a significant challenge: to convert 4.7 million tonnes per annum of high-pressure steam from the coking plant and an additional 20 million GJ/year thermal energy generated by the low-calorific BFG into electricity.

"Some of the BFG produced is used to heat the air for the hot blast stove. A switch-over of the hot blast stoves results in fast BFG flow changes that can only partially be recovered in the installed gas accumulators. Therefore a relatively high gas flow increase or decrease needs to be accepted by the power plant. Flaring of BFG by the safety system needs to be avoided as this would lead to losses."

The Alstom design team had also to juggle with steam parameters at the site. Bohtz explains: "The power plant needs to manage the energy network, consisting of an 18 bar low-pressure steam grid. When there is an excess of steam in the steel complex it may be used by the power plant. On the other hand, in case of a shortage in the network, the power plant must supply steam to the steel facility; it's a two-way road."

ThyssenKrupp's demands were very specific and determined at an early stage of the planning of the TKS CSA project. They were to include maximum output of electricity, minimum flaring within the gas systems entailing 100 per cent utilization of the by-product gases, and supervision and close control of both the high and low-pressure steam systems.

Alstom responded by building into the plant a high level of redundancy consisting of two independent units. In addition, the availability of each unit was to be greater than 92 per cent, with an energy unavailability of less than 2 per cent. Thermal efficiency of each unit would be 45 per cent for the low Btu CCPP. The environmental impact of the plant was to be as low as possible, exceeding the minimum local and international emission standards.

While, initially, both a conventional solution with BFG fired boilers and steam turbine and LBtu combined-cycle plant options were evaluated, the significant advantages of the latter soon became apparent, says Bohtz.

The option offered an efficiency in the rage 44–46 per cent, a shortened construction time of just 28 months, high operational flexibility, the possibility of operating the gas turbine in simple cycle mode using an installed bypass duct arrangement, very low NOx and CO emissions and a lower investment cost overall, compared to a boiler/steam turbine system.

These advantages would, however, come at a price. There would be the chance of power loss because of degradation and contamination, depending on gas quality and cleaning intervals of the gas turbine compressor and fuel gas compressor. The Alstom team also had to consider that ambient air temperature would be an issue, and this factor would have to be addressed by active cooling, using either evaporative cooling or over-saturation via high fogging.

In the final analysis, it was the promise of 92 per cent to 94 per cent availability, a construction time of 28 month (from order to start of commissioning) and lower initial investment cost that attracted ThyssenKrupp to the LBtu CCPP. Calculations showed that there would be sufficient BFG to operate both gas turbines in a optimal load range. In addition, a risk assessment showed there was parity between the CCPP and conventional solutions, with the former allowing a slightly higher expected annual production.

Bohtz says that Alstom, with its Plant Integrator approach, evaluated the project and developed an optimized power plant that best meets the specific requirements of the steel plant. "At an early stage, Alstom was able to rely on its design know-how as an OEM of the individual plant components and its broad experience from building power plants."

The KA11N2-2 CCPP has two GT11N2 LBtu gas turbines which drive the fuel gas compressors and provide approximately 90 MW each at an average ambient temperature of 25 °C. The exhaust heat from the gas turbines is recovered in non-reheat, horizontal type, heat recovery steam generators (HRSGs). The installed diverter damper allows the operation of the gas turbine also in simple cycle mode, providing additional flexibility.

Steam from the Alstom HRSGs serving the gas turbines and an additional 551 tonnes/h from HRSGs attached to the coke oven is used to drive an Alstom steam turbine producing 320 MW. The steam turbine is a three-casing configuration, with one high and two double flow low-pressure sections. The gas turbines drive an air cooled TOPAIR™ turbogenerator and the steam turbine a hydrogen-cooled TOPGAS™ turbogenerator. Alstom also supplied a water-cooled condenser and a distributed control system (DCS) based on its ALSPA P320 technology.

Through its new and fully integrated steel making complex in Brazil TKS CSA aims to boost high value exports to the United States and

Initially the plant was designed to run with the steam turbine consuming steam from the mill's boilers and with the gas turbines in simple cycle to bring it on-line as soon as possible, and then move to full production in combined-cycle as construction advances.

As TKS CSA has no coke oven gas available for the CCPP, the GT11N2 LBtu is ideally suited because it can run on pure BFG gas and does not require natural gas mixing. The fact that the gas turbines can be operated on BFG gas from 0–100 per cent electrical load with a high part load efficiency results in a very flexible power plant. Depending on the quantity of BFG, one or two gas turbines are in operation, either in simple cycle or in combined-cycle operation with additional steam imported from the coking plant.

GT11N2 LBTU DESIGN

Developed from the outset for the harshest of industrial service environments, the GT11N2 LBtu gas turbine includes Alstom's well-proven silo combustor. The LBtu unit has a 16-stage compressor with three variable guide vanes to allow the operation of the gas turbine with about the same turbine inlet flow as the standard GT11N2 by reducing the air inlet flow of the gas turbine air compressor to compensate the much higher fuel gas flow with BFG.

Europe, with the low-heat CCPP playing an important role in supporting this goal

The four Inconel 738 turbine stages feature a low stage load and excellent resistance in chemically aggressive environments. The first two turbine stages are cooled by compressed air. The monolithic rotor is welded from forged disks, resulting in a rugged and maintenance-free design. This unique technology has been successfully employed in thousands of Alstom gas and steam turbines for more than 60 years.

Normally the waste gases at steel plants are at low pressure – usually between 100 mbar and 250 mbar. At the TKS CSA plant, BFG from the blast furnace is first cleaned in a wet electrostatic precipitator and then compressed in two stages to about 16 bar for combustion in the gas turbine, which directly drives the fuel gas compressor.

The GT11N2 LBtu silo combustor was specially designed for the combustion of low-calorific gas. Considerably larger and higher than the standard single burner combustor of the GT11N2, the unit has to cope with LBtu fuel flows that are up to 20 times higher than would be the case using natural gas.

On the other hand, the lower combustion temperature leads to higher residence time in the silo combustion chamber. The combustor is functionally divided into two zones: a film cooled hot primary zone to ensure stable combustion with near stoichiometric air to fuel ratio and a cooler secondary zone for complete combustion with dilution air.

The LBtu burner is based on Alstom's experiences at no fewer than 21 earlier applications having between them more than two million fired hours. Some units have accumulated more than 260 000 operating hours. The burner has a diameter of 1.3 metres and has alternating slots for air and BFG, the size of the gas slots being designed to burn LBtu gases, and a minimum calorific value of 1800 kJ/kg can be achieved.

The air and the BFG leave the slots as a swirl to form a recirculating zone leading to a stable, nearly stoichiometric flame in the combustion chamber. This technology makes the GT11N2 LBtu the largest gas turbine capable of baseload operation exclusively burning low-calorific gases without blending with higher calorific gases.

POWERING THE STEEL INDUSTRY FOR OVER 50 YEARS

TKS CSA represents Alstom's most progressive foray into the bold world of steel making to date. Yet it has been building power plants for the steel industry for more than half a century. The gas turbine at Austria's Donawitz steel plant began operations in 1958 firing BFG and has accumulated more than 280 000 fired hours. Two more recent projects using the KA11N2 LBtu power plant technology are the Bao Shan project in China and Japan's Mizushima.

The first of these was built in 1994, for the Bao Shan Iron & Steel Corporation, the largest steel mill in China. There are similarities with the TKS CSA project, although Bao Shan is smaller and the 150 MW CCPP burns only some of the BFG from the steel mill in a GT11N2 LBtu gas turbine. This combined-cycle cogeneration plant is capable of producing 150 MW in full condensing mode or up to 170 tonnes/h steam for the steel mill. Alstom says the CCPP at Bao Shan achieved an even better overall performance than initially predicted, with a measured efficiency of 46.1 per cent and a measured power output of 154 MW. The average power train reliability reached 98.9 per cent during the three years period – April 1998 to March 2001.

The cogeneration plant in Mizushima, Japan, provides both electricity and process steam to a steel mill. Alstom says the gas turbine in simple cycle operation is providing 90 MW and the steam for the steel mill is generated in an HRSG. That project, also, was constructed to a very tight schedule, despite it being a custom built plant integrated in an industrial environment.

At both Bao Shan and Mizushima, the calorific value of the BFG has historically shown fluctuations within a range of at least ±10 per cent. These fluctuations are caused by the changing nature of the industrial sources feeding into the BFG supply system and therefore often occur instantaneously. In some exceptional cases, Alstom says, the heating value dropped to values as low as 1900 kJ/kg, yet the combustion process has remained stable under a variety of adverse conditions, showing no increase in emissions.

Bao Shan and Mizushima have also provided reliable data on NOx emissions using BFG, which are exceptionally low over the whole load range. Values of 1 volumetric parts per million (vppm) to 2 vppm (corrected to 15 per cent O_2) were repeatedly measured, representing the minimum detection level for commercial emission measurement systems for industrial installations.

Higher heating values and a different gas composition may lead to higher NOx emissions than measured at Bao Shan and Mizushima, but are expected to be always below 10 vppm with typical BFG composition. Measured CO emissions are well below 10 vppm, indicating that residence time in the combustor is sufficient to achieve nearly complete burn out of the approximately 20 per cent CO in the original BFG. Dust emissions are below 0.5 mg/Nm^3 without filtration in the stack. Pulsation levels during operation are below 15 mbar over the whole load range. These values are well below the original design assumptions, therefore significantly reducing actual mechanical loads due to pulsations on all hot gas path components.

THE ECONOMICS MAKE SENSE

Bohtz says the technology employed at TKS CSA represents a compelling argument for CCPP at steel plants. "Power generation costs are driven by several factors. For a BFG-based power plant your first concern is BFG fuel availability, but then there are investment costs, and further down the line the cost of electricity and steam; they're prime factors, which have to be evaluated against other types of power plants."

The benefits of using BFG where it is available soon begin to stack up, says Bohtz. "A representative case study for a typical BFG power plant shows that for a given BFG quantity at any steel mill, a KA11N2 LBtu would generate 25 per cent more power and steam compared to using conventional boilers. In other words, an additional 50 MWe could be generated in a KA11N2-2 LBtu plant with the same fuel balance in the steel mill. The initial investment of the CCPP will be faster amortized by the additional revenues from this power after a few years of operation. High electrical prices will further reduce the payback time of such an investment.

Economics are just one side of the coin, however. The argument in favour of CCPP gets better, says Bohtz. "You're getting other benefits as well. Add reduction of gaseous and particle emissions, as well as solid wastes, considerable savings of environmental control equipment, a reduction in specific carbon dioxide (CO_2) emissions due to better efficiency, any environmental tax premiums or other direct or indirect funding from governmental sources, and you're getting a clearer picture of why CCPP makes more sense.

"Then there are additional considerations associated with using this low end waste fuel more efficiently so that higher calorific fuels with limited availability, for example fuel oil, can be put to more valuable use in other industrial processes than power generation.

"When you compare the KA11N2 LBtu to other gas turbine based combined-cycle plants, the fact that the KA11N2 LBtu can use pure BFG and does not need natural gas or expensively cleaned coke oven gas brings an additional advantage that should be taken into consideration. Other gas turbines cannot burn pure BFG and need to blend the BFG with either coke oven gas or natural gas in order to achieve a higher heating value. Even if only 2 per cent to 3 per cent of the BFG mass flow needs to be added, the annual natural gas cost can run to tens of millions of euros."

With steel production rising to 55 million tonnes in 2008, no wonder that Alstom has now set its sights on India as a bigger future market for its technology. And Asia, as Bohtz is quick to point out. "India is the fifth largest producer of crude steel in the world and the world's biggest producer of direct reduced iron (DRI), or sponge iron, with close to 20 million tonnes production."

Following the liberalization and deregulation of the Indian steel market in the 1990s, a high growth in the steelmaking industry has been driven by both rising domestic demand and export. With private and foreign investment, large integrated plants are being expanded or under development. Recent plans for integrated steel plants include South Korean POSCO's plant and Mittal's plant, located in the states of Orissa and Karnataka respectively.

The technology applied at the TKS CSA plant in Brazil, and at Bao Shan and Mizushima, has demonstrated to effectiveness of generating power from waste gases.

Bohtz, again: "Some 40 MW to 50 MW of power can be generated from waste gases per million tonnes of annual oxygen steel making capacity, sometime even more. With a forecasted capacity of nearly 124 million tonnes in India in 2011–2012 and a potential efficiency increase from 30 per cent to 45 per cent using BFG in a CCPP, more than 800 MW can be generated additionally using combined-cycle technology. In total, the waste gases have the potential to generate 2500 MW in combined-cycle plants."

Moreover, says Bohtz, a further advantage is that the KA11N2 LBtu can be used both for new steel plants and as a retrofit solution for existing steel plants. With such efficiency increases, the additional power generation from the same amount of waste gases could contribute to a significant CO_2 reduction and the projects could qualify under the Clean Development Mechanism. Aside from generating revenues from power production, plant operators could benefit from additional support.

> *"The TKS CSA CCPP represents a winning solution, which could be adopted elsewhere as industrial operations resulting in waste gases are interested in improving their overall heat balance in order to reduce their electricity and energy consumption"*

PROJECT'S PROGRESS TO DATE

Commissioning of the first systems of the power plant began close to two years ago, with the water treatment plant, which serves different areas of the steel complex with demineralized water, followed by further balance of plant systems and the gas turbine and steam turbine units. All this is in line with the progress and sequence of the overall steel complex requirements.

The first firing of the first gas turbine unit of the CCPP took place in April 2010 and the second gas turbine followed in June 2010, marking major project milestones and the end of the erection and cold commissioning phase of the project. Achieving these milestones was very important to the client, as it signified not only the start of the hot commissioning of the gas turbines but also paved the way to support the steel complex with island operation capability, in case of grid failure. First start-up of the steam turbine is scheduled for September 2010 using steam produced by the coking plant.

Bohtz concludes: "The Brazil experience has shown the technology is capable of great things. And with steel making on the increase in Asia in particular we are convinced there are many more opportunities to take it to the next level."

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